Sky and TELESCOPE

Lehigh Valley amateurs

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The Origin of the Ancient Constellations

Radio Resolution of the Galactic Nucleus

Lehigh Valley Planetarium Project

Finding the Age of the Earth

April's Annular Eclipse in Australia

American Astronomers Report

Some Astronomical Stamps — VI

Stars for June

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JUNE, 1959

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Sky and TELESCOPE

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LETTERS

Sir:

What appeared in aerial photographs to be a large meteoric crater near Mt. Doreen in central Australia (see SKY AND TELESCOPE, July, 1957, page 429) was not caused by meteoritic impact, according to H. H. Nininger.

While visiting Australia recently, Dr. Nininger flew to the Mt. Doreen crater in a chartered plane. He said afterward that although a definite geological explanation of the formation could not be given, there was no raised rim, and the supposed crater lying inside a saltpan was actually a raised island with a central depression.

Dr. Nininger's visit was part of a trip to the Far East to investigate the distribution of tektites. In a talk to members of the Astronomical Society of South Australia, he reported that tektites collected by one enthusiast in Manila, Republic of the Philippines, must total nearly 500,000. Near Saigon, Vietnam, he himself had found nearly 800 within a few hours.

RALPH L. SANGSTER
111 Esplanade
Brighton, South Australia

Sir:

On page 321 of the April issue, in the Questions department, the query, "Are there any green stars?" is flatly answered "No." I am reminded of Nova Herculis 1934 as I saw it on several nights with the 100-inch telescope of the Mount Wilson Observatory. At one stage of its decline from maximum brightness, when its spectrum was showing the strong emission lines 4959 and 5007 of doubly ionized oxygen, that star was as green as a "Go" traffic light. Although the green light presumably came not from the star but from a nebulous shell, the latter was then so small that the shell and star were indistinguishable.

When astronomical observing was largely visual, the delicate colors of stars (always a mixture of spectral hues) were more generally noticed than they are now, and some strange terms were used to describe their beauty. The components of Beta Cygni were "yellow topaz" and "aquacoelestis blue," and Beta Librae was "pale emerald."

The companions of many stars, such as Antares, Gamma Andromedae, and Alpha Herculis, were plainly designated "green," and green they still appear. That this color is not entirely due to contrast with the brighter star is indicated by observations of occultations of Antares. In *The System of the Stars* (1905), Agnes M. Clerke describes such an event: "The small star, emerging from behind the Moon, seemed as perfectly green viewed thus alone as when half lost in the glare of the great red star it is attached to."

JOHN C. DUNCAN
Steward Observatory
Tucson, Ariz.

The Origin of the Ancient Constellations

GEORGE A. DAVIS

Sing praises to the Lord,
To him who rides in the heavens,
the ancient heavens.

Psalm 68, 32-33

ALTHOUGH the ancient star groups, which the whole civilized world has accepted and invested with a special and peculiar interest, were devised about 5,000 years ago, the writers on the constellations have differed as to how they actually took shape, and by whom they were brought into being. Probably no documentary evidence will ever be found that will settle this question definitely and satisfactorily for the astronomer. But I would like to call attention to some of the most recent findings concerning the Sumerians who, it is now agreed, originated the ancient star groups, and the possible bearing such facts might have on the manner in which the constellations were formed.[1]

Why did the ancient Mesopotamians call a certain group of stars MUL.MUL, "the constellation *par excellence*"; another group MUL.LIK.UTU, "the Dog of the Sun"; MUL.DUMU.ZI, "the Faithful Son"; MUL.GU.LA, "the Great Constellation" (representing the sky-god AN or Anu); MUL.GU.AN.NA, "the Heavenly Urn"; MUL.IM.DUGUD.KHU, "the Great Stormbird"; MUL.SIB.ZI.AN.NA, "the Faithful Shepherd of Heaven"; MUL.LUGAL, "the King"; MUL.KHA, "the Fish"; MUL.LULIM, "the Ram"; MUL.KHU.ZABA, "the Bird of the Forest"; MUL.AL.LUL, "the Exalted One"; MUL.KISAL.BAT.ALA, "the Ancient Altar Below"; and many others? Was it because the stars unmistakably impressed upon the mind of the observer these particular historical or mythological beings, objects, and animals? The origin of the constellation figures depends upon the answer to this question. Let us see, therefore, what some of the writers, both ancient and modern, have to say on this subject.

Aratus, in the third century B.C., was the first to assign a reason for dividing the stars into groups. He writes in his *Phaenomena* that "someone of the men that are no more noted and marked how to group [the stars] in figures and call all by a single name. For it had passed his skill to know each single star or name them one by one. Many are they on every hand, and of many the magnitudes and colors are the same, while all go circling round. Wherefore he deemed fit to group the stars in companies, so that in order, each set by the other, they might form figures. Hence the constellations got their names, and now no longer does any star rise a marvel from beneath the horizon."[2]

Cicero, somewhat later, said "the fixed stars were grouped in constellations so clearly defined that they have received names derived from their resemblance to familiar objects."[2]

Both writers, as well as other ancients, miss the point completely. Although Aratus gives us *a* reason for their origin, and Cicero begs the question in the finest scholastic fashion, neither attempts to explain *how* the constellations were formed, or by *whom*.

Among the modern writers, one says: "It is generally believed that those people [he has translated Aratus' 'someone' as 'people'] were shepherds, nomads of the desert, mariners, scholars, astrologers, and others who dwelt in the Tigris and Euphrates valleys and neighboring regions." And the same author goes on: "If we ourselves had been the originators, we might have chosen about the same groupings of stars and something like the same plan of naming them. . . . Let someone who cannot recognize a single constellation go out and view the sky after dark tonight. . . . He will most likely be attracted by the same figures that impressed the watchers of long ago."

Such statements are easily made and sound very scholarly and convincing, but the Sumerian constellations mentioned above, and the sky itself, are a sufficient refutation of all such conclusions.

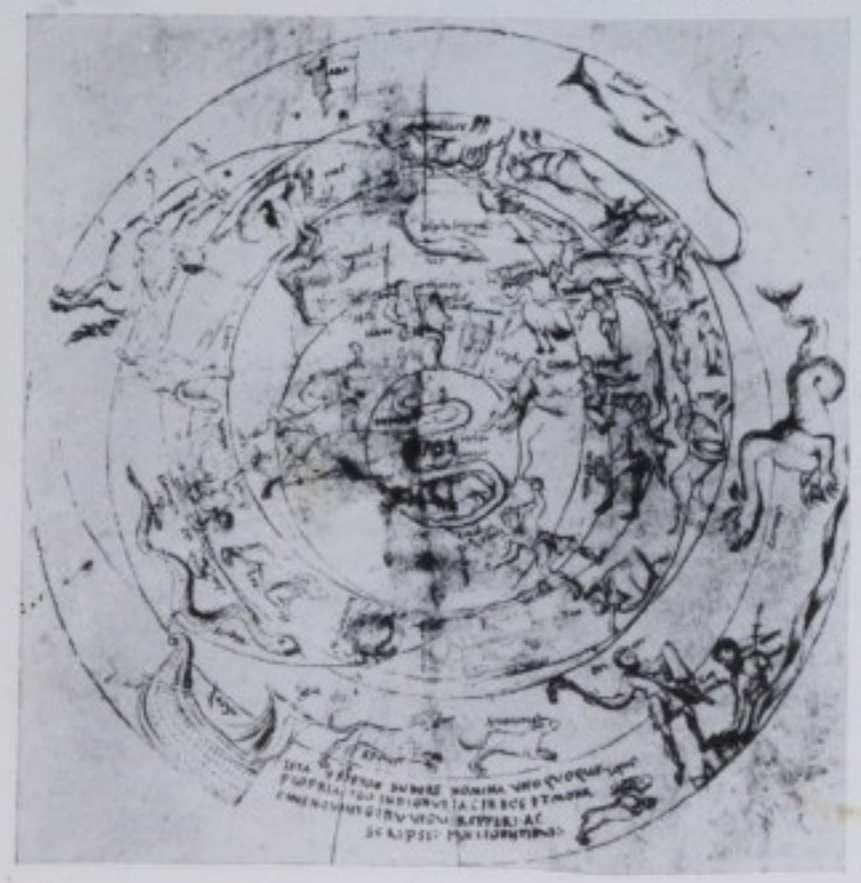
Again, we are told to "imagine a group of Chaldean shepherds whiling away the hours of night watching the slowly moving heavenly pageant. One of them points to the constellation we now call Orion and remarks: 'Does not that look like the figure of a man?' . . . As time went on, the watchers of the skies picked out more groups of stars which seemed to have definite shapes." And then follows a most remarkable statement about the star groups that have survived for thousands of years: "People perhaps made a sort of game of identifying them with figures of animals or men."

An ingenious speculation that the constellations developed from the original cuneiform scripts which were later attached to the stars and formed "pictorial designs" is highly interesting, but hardly convincing.[4]

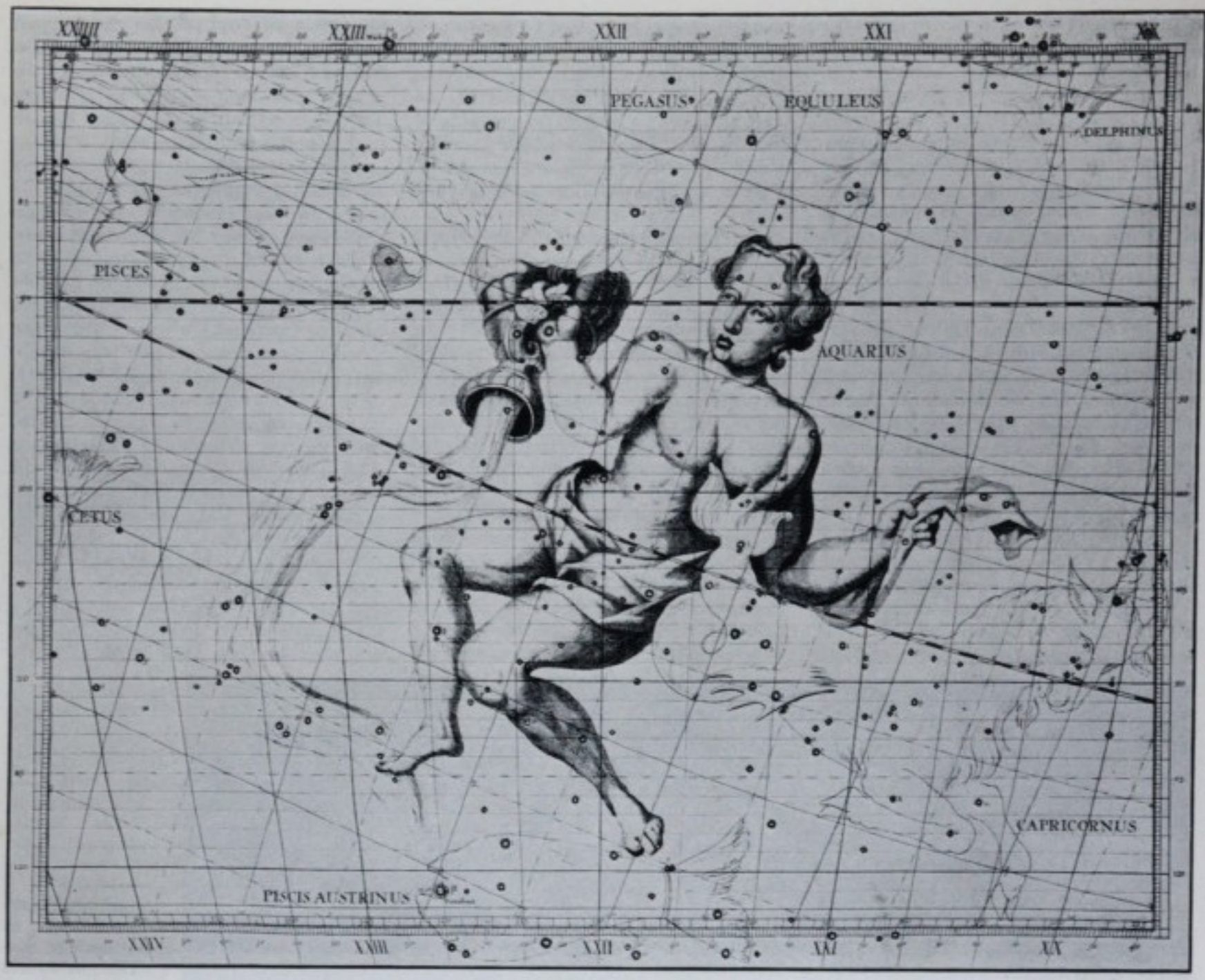
Some other modern authors, however, feel that the origin of the star groups is not so simple as the views expressed above seem to imply.

Clyde Fisher, in discussing the resemblances between the objects and their names, says, "In some cases the resemblance is evident to us, but in others we wonder at the imagination that suggested the name."[3]

H. Spencer Jones remarks: "In a few cases a fanciful resemblance may be seen between the outline of a constellation and the object from which it derives its name, but in general no resemblance can be



This illustration from a manuscript of the 9th or 10th century A.D. is one of the oldest existing constellation maps. It was drawn to illustrate the "Phaenomena" of Aratus. At the center note winding Draco with the Bears in its curves, and Cassiopeia without a chair. In the upper right, water flows from the jug of Aquarius; at the right, Cetus is a sea monster rather than a whale. From Basil Brown's "Astronomical Atlases, Maps, and Charts."



To the inhabitants of ancient Sumer, the zodiacal constellation we know as Aquarius was a representation of their sky-god AN. This drawing of the Water Carrier is from the famous star atlas of John Flamsteed, the second Astronomer Royal. His maps were published under the title "Atlas Coelestis" in 1729, 10 years after he died. Faintly outlined are parts of some adjoining constellations, such as the Water Goat, Southern Fish, Dolphin, and the Fishes, as well as the Winged Horse and its Colt. This map has two grids: for right ascension and declination, and for celestial longitude and latitude.

seen nor can any reason be assigned for the name."[6]

Richard H. Allen, whose great book on star names is a starting point for all studies of the constellations, tells us: "The constellations . . . in ancient times were confined within the outlines of the forms that they were supposed to represent, although any resemblance was only occasionally noticeable."[7]

A. C. D. Crommelin is perfectly straightforward in his views: "It is fairly evident that the constellations were not wholly, perhaps not even mainly designed from fancied resemblances between them and the objects whose names they bear; there is such resemblance in a few cases, but in others the figure was chosen as part of a symbolical scheme."[8]

And finally, Sir Arthur Eddington and Charles Everitt do not hesitate to affirm: "From the earliest times the star-groups known as constellations have received names symbolizing religious or mythological beliefs."[9]

The Sumerians, among whom the ancient constellations were formed, flourished in southern Babylonia from the beginning of the fourth millennium B.C., and perhaps many years earlier, to the end of the third millennium B.C. During this long stretch of time they represented the dominant cultural group of the entire Near East. They developed religious and spiritual concepts, together with a remarkably well-integrated pantheon, which influenced profoundly not only the peoples of Mesopotamia but the Hebrews and the Greeks."

This civilization was the highest in the then known world; yet no astrological documents of purely Sumerian origin have ever been found.[11] "The more mature and reflective Sumerian thinker had the mental capacity of thinking logically and coherently on any problem, including those concerned with the origin and operation of the universe. His stumbling block was the lack of scientific data at his disposal."[12]

The importance of religion in the origin of the constellations is well shown by the most beautiful and comprehensive description I have ever seen of the attitude of the ancient Sumerian to the sky and the god who dwelt therein:

"Anu, the highest of the gods, was god of the sky, and his name was the everyday word for 'sky.' The dominant role which the sky plays — even in a merely spatial sense — in the composition of the visible universe, and the eminent position which it occupies, high above all other things, may well explain why Anu should rank as the most important force in the cosmos. . . . The sky can, at moments when man is in a singularly receptive mood, reveal itself in an almost terrifying experience. The vast sky encircling one on all sides may be felt as a presence at once overwhelming and awesome, forcing one to his knees merely by its sheer being. And this feeling which the sky inspires is definite . . . and is that inspired by majesty. There is in it the experience

of greatness or even of the tremendous. Then comes a keen realization . . . of unbridgeable remoteness. . . . But, though a feeling of distance, this feeling is not one of absolute separation; it has a strong element of sympathy and of the most unqualified acceptance. This majesty and absolute authority which can be experienced in the sky, the Mesopotamians called AN or Anu, and he was the overpowering personality of the sky."[13]

This exalted idea of the sky was not expressed again for 2,000 years, when the Judean shepherd sang of the glory of God and His handiwork being proclaimed by the heavens and the firmament.[14] And a somewhat similar thought was stated by Aristotle many centuries later when he called the outermost and uppermost region of the sky *ouranos*, as that part "in which we believe all divinity to have its seat."[15]

Bearing in mind the above facts concerning the Sumerians, is it conceivable that the constellations of their sky-god AN would be those chosen, apparently without rhyme or reason, by shepherds, sailors, nomads of the desert, and the common people generally? I do not think so; and I believe that an impartial observer would admit that the constellations, such as those mentioned at the beginning of this article, do not remind him of the figures after which they are named — in other words, the natural arrangement of the stars does not sufficiently resemble such forms.

The ancient constellation designer, be he priest, priest-king, or king, had already in his mind certain figures which represented ideas that he wished to project on the sky; and he accommodated the natural arrangement of the stars to these figures. Thus, he arranged the stars of the constellation we now call Aquila into the representation of an eagle (MUL.ID.KHU), not because they naturally reminded him (or anyone else) of an eagle, but simply because, for one reason or another, he wished to express that idea.

Of course, the actual configuration of the stars sometimes naturally suggested certain figures which were utilized to form stellar groups if they were consistent in other respects with the ideas of the framer, such as the Crown (MUL.GIL), the Great Serpent (MUL.SIR.GAL), the Scorpion (MUL.GIR.TAB), and the Long Chariot (MUL.MAR.GID.DA), but by far the greater number were not formed in this way. They were created by the framer because they represented figures that had unmistakably a religious, mythological, or cosmological significance to him and his associates. And having these fixed ideas already in his mind, he applied the figures to the stars and the stars to the figures as harmoniously and as carefully as possible.

This concept, I believe, shows that the primitive constellation figures had a preconstellational history. They were actually forms and phases of thought familiar to early man, who was well acquainted with the stars, but before he seriously entered upon the task of inventing constellations. This is why he selected the ones he did.

Thus, many primitive stellar groups are duplications of ideas connected with some natural phenomena — solar, lunar, or otherwise. The sun, for example, is described in many ways among the ancients, and is often personified and called a shepherd, warrior, archer, hunter, water pourer, charioteer, horse, eagle, and the

Some 2,000 years ago a carving of the ancient constellation figures was made to decorate the ceiling of a temple of Isis at Denderah, in Egypt. The original sandstone slab was moved to Paris in 1820. This is a copy of a drawing by an unknown artist, from a book published at Paris two years later. Many of the zodiacal figures are easily recognized here. For example, look for Leo the Lion and Cancer the Crab slightly below left center.

like. On the other hand, darkness, the enemy of the sun, may take the form of a huge dragon, serpent, or scorpion. And the moon is naturally thought of in connection with a bull, ox, or cow.

In the history of the constellations, both the literary references to them and the adaptation of the forms to the actual stellar configurations show that we cannot accept the constellations as pictures of objects noted by lonely shepherds, nomads of the desert, mariners, and others, whose observations of the stars were merely casual and without any religious or mythological significance.[16]

My own belief may be expressed:

A priest of ancient Sumer years ago,
While worshiping his God of heaven, known
To him as AN, and wishing to engrave
Upon the sky the objects of his thoughts
And persons sacred to him and his God,
For men of all the ages destined to live
Upon this earth and look upon the stars,
Conceived of certain figures which to him
Seemed proper to express forever the love
And adoration felt by man for Him
Who made and governs sky and earth and sea
And all the waters underneath the earth.

NOTES

1. Diacritical marks, points and signs, vowel quantities, accents and the "third h" are not available for use in this article. And I have taken the "ancient constellations" to be those mentioned by Aratus.

2. *Phaenomena*, 370-382, in the Loeb Classical Library.

3. *De Natura Deorum, II*, xl, 104.

4. Morris Jastrow, Jr., *The Religion of Babylonia and Assyria*, 454-456, 1898.

5. *Exploring the Heavens*, 127, 1937.

6. *General Astronomy*, 285, 1925.

7. *Star-Names and Their Meanings*, 10, 1899.

8. T. E. R. Phillips and W. H. Steavenson, editors, *Splendour of the Heavens*, 645; Peter Lum, *The Stars in Our Heaven*, 162, 1948.

9. *Encyclopaedia Britannica, VI*, 311, 1952 edition.

10. Samuel Noah Kramer, *Sumerian Mythology*, vii; Stephen Herbert Langdon's "Semitic Mythology" in *The Mythology of All Races, V*, 1-10, 1931.

11. O. Neugebauer, "The History of Ancient Astronomy: Problems and Methods" in *Publications* of the Astronomical Society of the Pacific, *58*, 38 ff., 1946; *Journal of Near Eastern Studies, 4*, 1-38, 1945.

12. Samuel Noah Kramer, *From the Tablets of Sumer*, 76, 1956.

13. Thorkild Jacobsen, *The Intellectual Adventure of Ancient Man*, 137-138, 1946; also, the Penguin book *Before Philosophy*, 150-151, 1954.

14. *Psalm 19*, 1.

15. *On the Heavens, I*, ix, 278 b 15.

16. On this entire subject I recommend Robert Brown, Jr., *Primitive Constellations*. See especially *I*, 127 ff., and *II*, 220-226. For an excellent summary of the importance of ancient Mesopotamian astronomy, read A. T. Olmstead's "Babylonian Astronomy" in the *American Journal of Semitic Languages and Literatures, LV*, 114, 1938.

ASTRONOMICAL SCRAPBOOK

THE S FORNACIS PUZZLE

VARIABLE STAR ASTRONOMY has many disquieting small problems that have gone unsolved for years — paradoxical observations that did not fit any reasonable scheme and so were swept under the carpet and forgotten.

Often that is where they should remain, because the recorded facts are too scanty and uncertain for any successful reconstruction. In other instances, however, the observations were made by experienced astronomers and reported in full detail. In these cases, it is worth turning up the carpet for another look.

Belonging in the latter category is the case of an 8th-magnitude star in the southern constellation Fornax, close to the Eridanus boundary, at right ascension $3^h\ 44^m.1$, declination $-24°\ 33'$ (1950). Since the year 1900, it has been listed in the variable star catalogues as S Fornacis. This distinction is precarious, however, and rests solely on the peculiar behavior of this star on March 6, 1899.

Four nights before that date, the California amateur astronomer Lewis Swift had found a new naked-eye comet low in the southwest during evening twilight. Comet 1899a was promptly confirmed at Lick Observatory, and the news was wired to Harvard and thence to Europe, where many observers located the new object on March 6th.

At Arcetri Observatory, in Italy, A. Abetti used an 11-inch refractor to measure the position of the comet relative to three neighboring stars. One of the three was the star later to be called S Fornacis, which to his surprise seemed of magnitude 5 or 6, instead of the 8 or 8½ given in the star catalogues.

Nearly simultaneously, at Bamberg Observatory in Germany, E. Hartwig with a heliometer was observing the comet's place relative to S Fornacis. He too was struck by its unexpected brightness, which made it difficult to identify the star field.

A third astronomer who used the same star as a comparison object for observing Comet 1899a on March 6th was J. Holetschek at Vienna, with a 6-inch refractor. He reported that the star appeared much brighter than its catalogued magnitude, and that in his finder the total brightness of the comet matched that of the star.

Thus we have three experienced astronomers, using adequate instruments at regular observatories, who independently noted the star as abnormally bright. There can hardly be any possibility of misidentification, as the comet positions they deduced from comparisons with the star fall accurately on the track of the comet. The Greenwich times of their observations were: Vienna, 6:37 p.m.; Arcetri, 6:48 p.m.; and Bamberg, 6:54 p.m. At 6:13 p.m. a fourth astronomer, E. Millosevich of Rome, had also used S Fornacis as a comparison star for the comet without, however, reporting anything about its brightness.

This part of the sky was soon lost in the evening twilight. When the region could be seen again, in the morning sky in August, 1899, the star was faint, according to Hartwig and Holetschek. Since that March night 60 years ago, S Fornacis has never been observed brighter than its normal magnitude of 8. The most extensive check was Cecilia Payne Gaposchkin's examination of about 400 Harvard patrol plates, which showed the star always at its normal faintness.

Are we then dealing with a star that on a single occasion brightened by 2½ or three magnitudes for a short while? This interpretation was flatly denied by E. C. Pickering on the basis that a Harvard photograph, taken on the critical evening of March 6, 1899, showed the star at its ordinary brightness. From the observatory record books, it appears that this plate was I 22535, taken at Cambridge, Massachusetts, with the 8-inch Draper refractor by E. S. King, for the purpose of securing a picture of the comet. But the middle of the 15-minute exposure was 7:20 p.m. Eastern standard time, 5½ hours later than when the European observers noted S Fornacis as bright.

Hence, if the star actually varied, its outburst could have had a duration of only a few hours at most. This would have seemed incredible when Pickering wrote in 1907, but today we are familiar with flare stars which show large increases in brightness lasting only a few minutes.

There is, however, a difficulty in calling S Fornacis a flare star. According to the *Henry Draper Catalogue*, its spectrum is of class *F*8, without any conspicuous peculiarity, while the recognized flare stars are *M*-type dwarfs with emission lines of ionized calcium. But S Fornacis is a very close double star, as R. A. Rossiter discovered in 1933 with the 27-inch refractor of Lamont-Hussey Observatory in South Africa. If the fainter component is a peculiar star, its spectral characteristics may be masked by the light of the brighter *F*8 star.

And here the problem rests at present. It would be worth while to observe the star with a slit spectrograph attached to a large telescope, which might provide a clue not apparent on the low-dispersion objective-prism plates from which the Draper spectral classification was made. It seems definitely desirable for variable star observers to check the star's brightness from time to time. After all, to catch S Fornacis at another maximum could provide the most conclusive evidence possible as to what really happened on March 6, 1899!

JOSEPH ASHBROOK

In a broad valley lying between 4,000-foot mountain ranges, with good protection from man-made radio interference, is located the new 85-foot parabolic radio telescope of the National Radio Astronomy Observatory at Green Bank, West Virginia. The resolution of the Sagittarius A source into discrete components at 3.75 centimeters is one of the first discoveries made with this instrument, which began operation last October. Photograph courtesy Associated Universities, Inc.

Radio Resolution of the Galactic Nucleus

FRANK D. DRAKE, *National Radio Astronomy Observatory*

THE DISCRETE SOURCE of radio emission known as Sagittarius A is one of the most intense in the whole sky. Because it lies very nearly in the direction of the galactic center, many radio astronomers have regarded Sagittarius A as the actual nucleus of our Milky Way galaxy, and the recently adopted new system of galactic co-ordinates (see page 383 of last month) employs this source as the zero from which galactic longitude is counted.

At the National Radio Astronomy Observatory, Green Bank, West Virginia, the writer has resolved Sagittarius A into at least four component parts, using the new 85-foot Tatel radio telescope. This represents one of the first results obtained with this instrument, and indicates that parts of the source are not really located exactly at the galactic center.

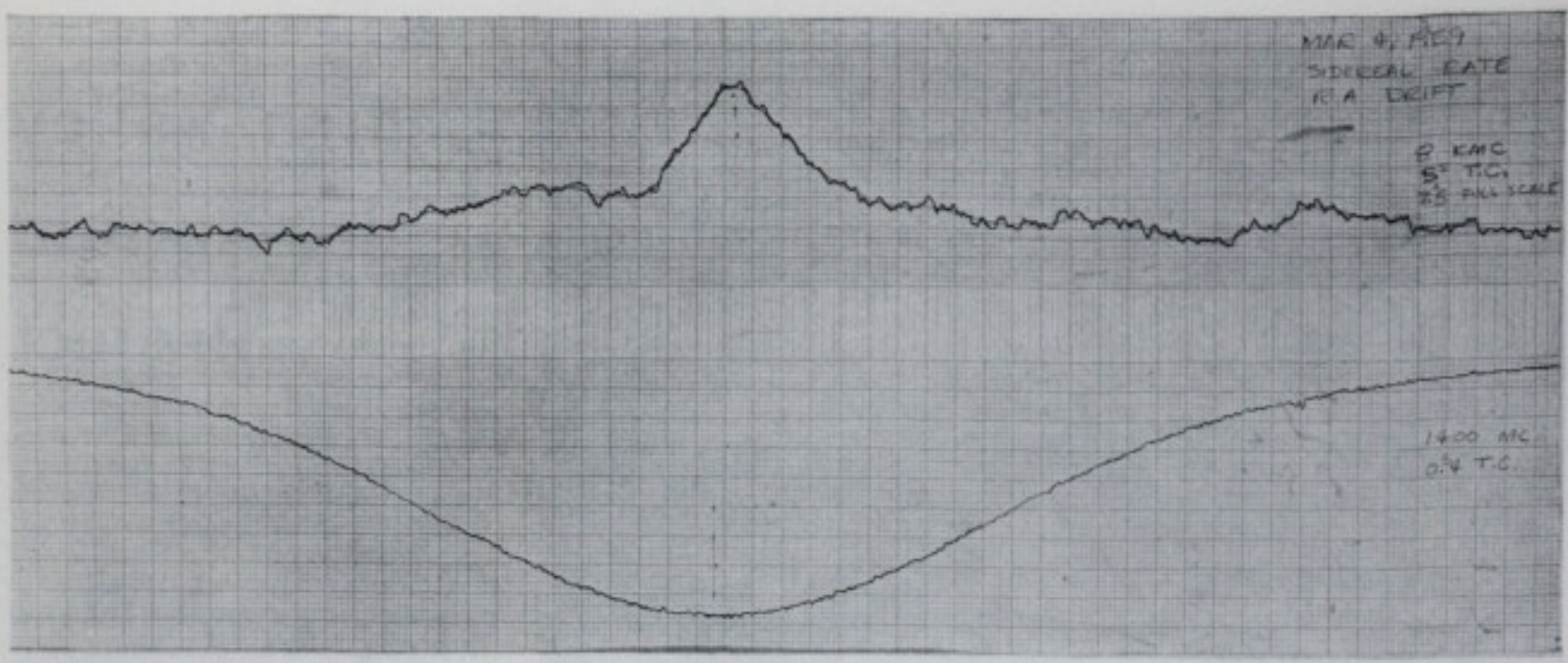
The 85-foot reflector was fitted with two concentric horns built by Jasik Laboratories, which allowed simultaneous observations at 22- and 3.75-centimeter wave lengths. The antenna beam-width at 22 centimeters was 36 minutes of arc, and six minutes at 3.75 centimeters. Observations consisted of taking drift curves in both right ascension and declination across the most intense portion of the Sagittarius A radio source.

A typical record obtained is reproduced here. The 3.75-cm. curve is the top one, and the simultaneous 22-cm. record is the inverted bottom tracing. The most striking feature is the resolution of the source into many components by the six-minute beam, illustrating the improvement in resolution of a given radio telescope at shorter wave lengths.

Four individual features are discernible here. The most intense is somewhat broadened, and has close, high-intensity wings. The apparent position of the Sagittarius A source, as indicated by the 22-cm. curve, does not fit any of the 3.75-cm. components, but seems rather some center of brightness for the complex of sources. The strongest 3.75-cm. component is actually about two minutes of arc from the 22-cm. position.

The mean values of eight tracings in right ascension are plotted in one diagram, and verify the structure indicated by the sample record. In similar tracings made by scanning in declination, resolution into several sources is obtained, and again the strongest differs from the 22-cm. Sagittarius A position, by about three minutes of arc.

To test the reality of these differences, David S. Heeschen and I have observed



These two tracings of the Sagittarius A radio source were obtained on March 4, 1959, with the Green Bank 85-foot radio telescope. The top curve records emission at 3.75 centimeters wave length, and shows resolution of the source into several components. The bottom curve, which is inverted, is a simultaneous recording at 22 centimeters, and shows the center of brightness of the complex. The time constants for these two tracings were five seconds and 0.4 second, respectively. The illustrations on this page are from the National Radio Astronomy Observatory.

the apparent positions of many bright radio sources at both wave lengths, using the concentric horn feed. Three sources of small angular size, Cassiopeia A, Cygnus A, and Taurus A, all have declination differences of zero, to within a few seconds of arc. The extended sources have much larger deviations, as is to be expected.

Observing times of the order of 10 minutes produce relative positions accurate to better than 10 seconds of arc. NRAO will shortly install equipment capable of making *absolute* position measurements, still to 10 seconds of arc or better.

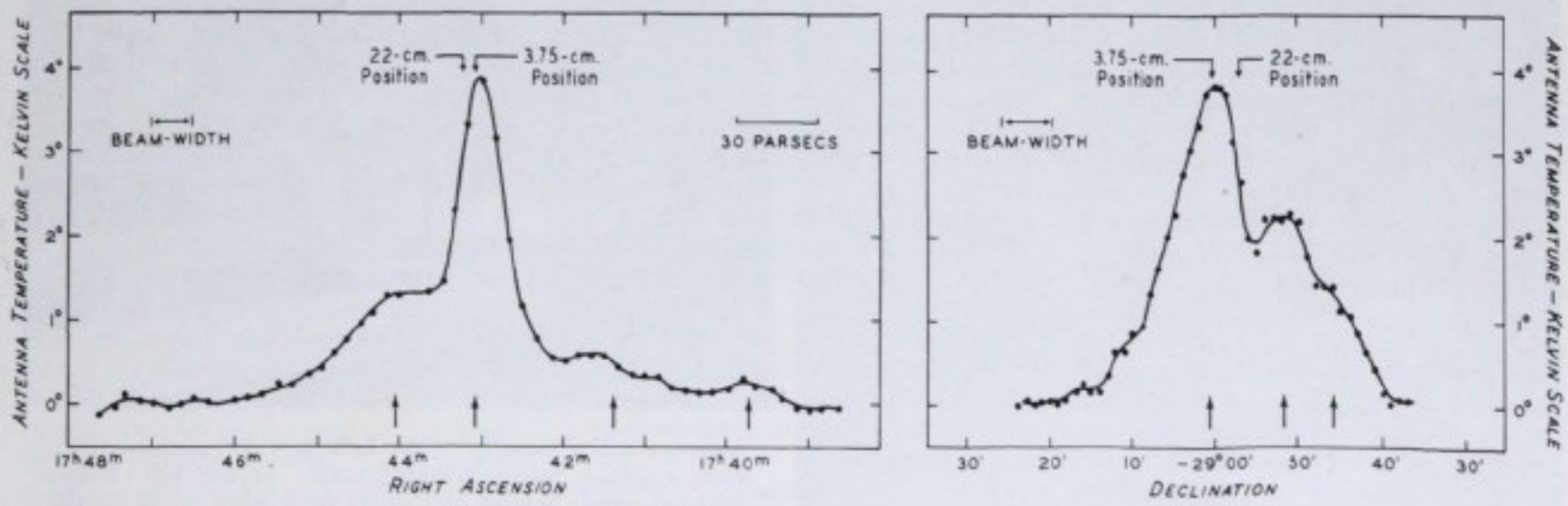
These results require a revision of our ideas regarding the physical structure of the galactic nucleus. The question is raised of whether one of these observed components is the nucleus, the others being subordinate to it, or whether the nucleus consists of a conglomerate of physically similar structures. A radio map of this region is now being made at Green Bank to help clarify the foregoing preliminary results. Our observations are nearing completion, and soon should permit us to solidify our conclusions.

A few galaxies have been observed optically to have complex nuclear regions, possibly like ours. Among such systems are NGC 1808, 3351, 4321, and 5248. W. A. Baade has found the central nucleus of the Andromeda spiral (M31) and those of some other galaxies to consist of small bodies about 20 parsecs in diameter (65 light-years). The broadening of the strongest component we have observed in the Milky Way nucleus indicates that this object is about 20 parsecs in diameter, thus matching Baade's measure of the typical diameter of galactic nuclei. On this basis, then, we tentatively conclude that one of the observed components — probably the brightest — is actually the galactic center.

If further investigation bears out this conclusion, the 22-cm. position of Sagittarius A is not the position of the nucleus, and the new zero point of galactic longitude, which is based on this 22-cm. position, differs by several minutes of arc from the galactic center. This would put the center of our system at galactic longitude 359°.95 in the new International Astronomical Union system.

OTTO STRUVE APPOINTED DIRECTOR AT GREEN BANK

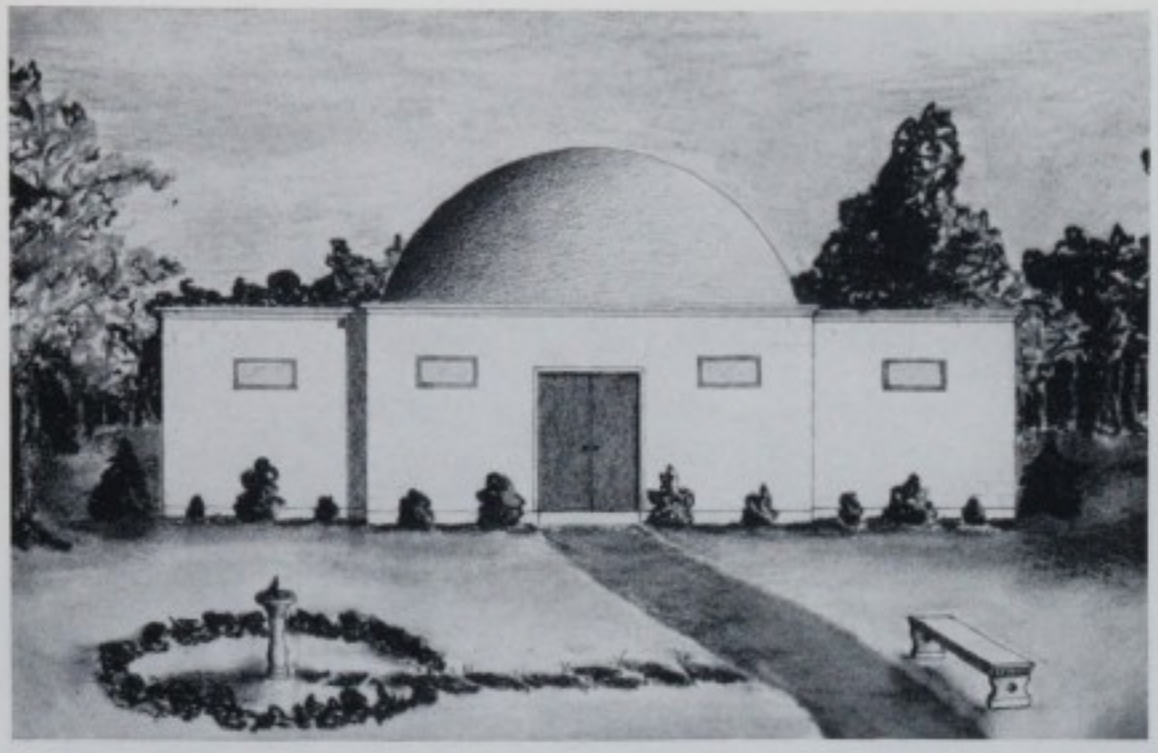
The first director of the National Radio Astronomy Observatory at Green Bank, West Virginia, will be Otto Struve, who is presently director of Leuschner Observatory at the University of California. Dr. Struve will assume his new position on July 1st. Before going to Berkeley in 1950, he was in charge of the Yerkes and McDonald Observatories from 1932 to 1947.



The structure of the Sagittarius A radio source at 3.75 centimeters wave length is shown by the average of eight tracings in right ascension. The declination curve is preliminary, and more extensive observations are currently being made. Arrows indicate the individual components of the source. The vertical scale is antenna temperature in degrees Kelvin, a measure of the radio energy received by the telescope; the probable error of each point is about 0.04° K.

Lehigh Valley Planetarium Project

JOSEPH F. GRADY
Lehigh Valley Amateur Astronomical Society, Inc.



This drawing by Gloria Leight shows how the Lehigh Valley planetarium will appear when construction is completed and the grounds are landscaped.

TWO BASIC PURPOSES led to the founding of the Lehigh Valley Amateur Astronomical Society in Bethlehem, Pennsylvania, on October 6, 1957. They were to encourage interest in amateur astronomy, and to construct a combination planetarium and meeting place.

Success in our first aim is proven by our membership of nearly 50 adults and some 30 active juniors. The second aim is near fulfillment, as the planetarium building will be completed by late summer or early fall.

At first, the society was made up of Bethlehem amateurs, who met at the home of the writer. Another Lehigh Valley club, with its headquarters in Allentown since 1936, merged with the Bethlehem group because of our proximity and mutual interests. The American Legion home in Bethlehem was used as a meeting place for the enlarged club.

An enthusiastic search then began for a planetarium site. A small airplane was chartered by Edwin J. Gilmore, Jr., to survey high elevations, but suitable sites he located were either not for sale or were too expensive.

Hearing of the club's plight, Raymond Kohn and Harry Dower, owners of radio station WFMZ and 15 acres of land on the highest point overlooking the valley, gave the society one acre of land and roadway rights. This site is in Salisbury Township, midway between Allentown and Bethlehem, at an elevation of 1,000 feet.

In the spring of 1958, after our plans were drawn up, work parties were organized on weekends. Over 100 trees were cut down to make a road and a clearing for the building. A bulldozer was rented to remove the tree stumps and grade the road, which required over 28 truckloads of fill. While this operation was in progress, the society constitution and bylaws were adopted, and we became incorporated.

By June the foundation was started and about 7¼ cubic yards of concrete were poured. The outside dimensions of the building are 42 by 26 feet. The height is 14 feet, exclusive of the dome, which is 20 feet in diameter and is fabricated from 32 sections of hardwood. The dome will be covered with 22-gauge aluminum sheets.

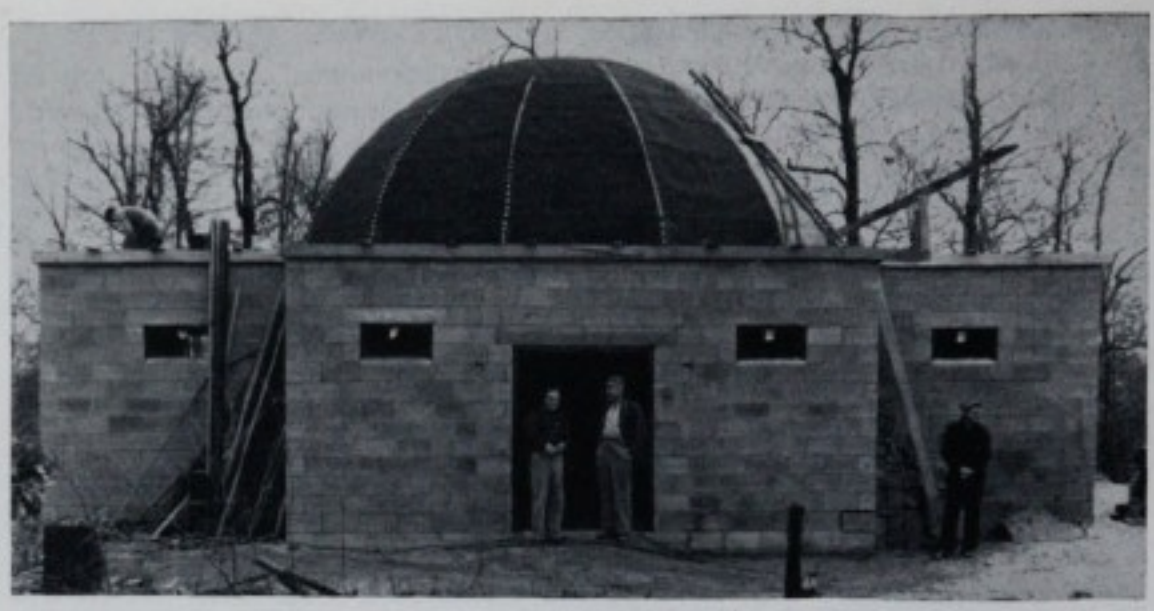
Above, a senior member of the Lehigh Valley society supervises a junior mirror-grinding class. At the left, Ralph Schlegel stands behind his display of finished parts for the planetarium's six-foot projector. Directly in front of him is the cage that holds the units that project the planets. All photographs by Walter W. Leight.

The planetarium is to house a six-foot-long projector, which will produce the constellations, stars to the 6th magnitude, the planets and their motions in the sky, and the phases of the moon. It is the product of Ralph Schlegel, who began building it in 1954 and expects to be finished early in 1960. After many years of research and study, Mr. Schlegel made his own patterns and castings, machining all gears, shafts, and optical cells.

It is planned to feature planetarium demonstrations on weekends, with a small admission fee to make the building self-supporting. In time, an observatory may be added to house a 12½-inch Cassegrainian reflector, which is now in the drawing stage. Several members are presently constructing an equatorial mount, to be located in an observing area behind the building, to accommodate a 6-inch refractor donated by a member, Dr. D. George Knecht.

The society received no outside financial assistance in this project, all costs of building materials being contributed by members. Although the building had been used by the junior group and telescope making classes, the first general meeting in the new quarters was held on May 3rd of this year. The purchase of 50 folding chairs made this possible.

Members in the Lehigh Valley society are men and women from many walks of life: housewives, secretaries, artists, optical men, painters, carpenters, machinists, geologists, research men, doctors, and salesmen. The senior members own 41 telescopes, ranging from a 19-inch reflector to a 2.4-inch refractor (some of these are pictured on the front cover).



The planetarium building as it looked early last winter. The 20-foot dome will be covered with aluminum sheets.

The largest instrument, made by Walter W. Leight, is unusual in having a primary mirror less than 0.9 inch thick at its center. It is f/3.9, the focal length being 75 inches, yet the 19-inch mirror holds its figure very well, as it is made of a special piece of reannealed plate glass.

Our present officers are William Ference, director; Joseph F. Grady, assistant director; Mr. Schlegel, treasurer; and Mrs. O. George Lewis, secretary. The society publishes a monthly bulletin, *Satellite*.

On May 15th, the first of three public star parties was held on city-owned property in Bethlehem. The program included astronomical displays, motion pictures, and planetarium shows under a portable 10-foot dome with a Spitz, Jr., projector. Over 30 telescopes were also set up, each manned by a member.

Amateur Astronomers

A New 16-inch Telescope in Texas

RECENTLY I installed a 16-inch Newtonian reflector in my Skyview Observatory to replace an older one of the same size that was sold some time ago. Weighing about 1¼ tons, the new instrument is more suited for astrophotography.

The entire instrument was made in California. Amateur astronomer Claude B. Carpenter of Romoland supervised its construction, and Leland S. Barnes, Pasadena, finished the 16-inch mirror of 88 inches focal length.

The fabricated steel pier has adjusting screws at each corner, and is mounted on a 38-by-40-inch concrete foundation which extends five feet into the ground. The pier foundation is separated from the observatory floor to help minimize vibration.

The 3½-inch-diameter polar axle is chrome molybdenum steel. The declination axle, of the same diameter, is five feet long, and its housing is steel one inch thick. Equipped with illuminated 16-inch circles, the instrument has a slip circle for right ascension, separately driven. A heavy 18-inch-diameter gear is used on the polar axle for the sidereal drive. Push-button slow motions in both co-ordinates are powered by Bodine motors.

A 6-inch f/12 refractor, not pictured, is mounted on the tube to serve as a guiding telescope.

An added convenience of the Skyview Observatory telescope is the threaded end of the declination axle, which permits the counterweights to be moved by handwheels in either direction.

Amateurs visiting the Eagle Pass, Texas, area are invited to come to this observatory.

J. RUSSELL SMITH
Skyview Observatory
Eagle Pass, Tex.

THIS MONTH'S MEETINGS

Albany, N. Y.: Albany Amateur Astronomers, 8 p.m., Dudley Observatory. June 8, Mrs. Harry R. Bain, "Our Galaxy." June 22, John Dugan, "Other Galaxies."

Chicago, Ill.: Chicago Astronomical Society, 8 p.m., Adler Planetarium. June 12, Dr. W. W. Morgan, Yerkes Observatory, "Some Applications of Spectroscopy to Problems of the Structure of Galaxies."

Edinburg, Tex.: Magic Valley Astronomical Society, 8 p.m., science building, Pan American College. June 19, Lt. Eugene D. Rowell, Harlingen Air Force Base, "Celestial Navigation."

Whittier, Calif.: Whittier Amateur Astronomers, 7:45 p.m., Bailey Recreation Center. June 16, Dr. H. P. Kerfoot, North American Aviation, Inc., "The Special Theory of Relativity."

FIRST AMATEUR OBSERVATORY IN CALIFORNIA

The Sacramento Valley and Stockton astronomical societies are erecting a monument to mark the site of the first amateur observatory in California, at the town of Volcano in Amador County. The observatory was built in 1860 by a mining engineer, George Madeira, who independently discovered the great comet of 1861 with his 3-inch equatorial refractor.

In the April issue of the *Griffith Observer*, Victor W. Killick, of Sacramento Junior College Observatory, summarizes

the 10,000-word report he has filed with the California State Historical Society on his findings about Madeira's observatory. Mr. Killick's project took over three years to complete.

Although the remaining ruins of the observatory were cleared away some 50 years ago, according to Edward Lehn of Stockton, last September 29th he led Mr. Killick directly to the site. The monument will be temporary, as it has been suggested to the historical society that a permanent one be erected to commemorate this pioneer observatory.

LOS ANGELES STAR PARTIES

The Los Angeles Astronomical Society is currently holding a series of monthly star parties. On June 6th, July 11th, and September 12th, this group will meet at Charlton Flats, some five miles due north of Mount Wilson Observatory and at about the same elevation. The Menifee Valley Observatory will be visited on August 8th, and on October 3rd there will be a joint star party with the Inyokern Astronomical Society at China Lake. Further information may be had from Chalmers B. Myers, Box 78-D, Romoland, Calif.

NORTHWEST CONVENTION

The 12th annual convention of the Northwest Region of the Astronomical League will be held at the College of Puget Sound, Tacoma, Washington, July 18-19. The Tacoma Amateur Astronomers are sponsoring the meeting.

Dr. R. M. Petrie, director of the Dominion Astrophysical Observatory at Vancouver, British Columbia, will be guest speaker. The registration fee of $1.00 for an individual or $1.50 per family may be sent now to Mrs. Virginia Cummings, 7512 Chambers Creek Rd., Tacoma 6, Wash.

CHICAGO JUNIOR PUBLICATION

Members of the Searchers Astronomical Society, a junior group, have been publishing a mimeographed monthly magazine, *Celestial Guide*, since last January. The 16-page April issue contained an article by Dr. Dan Q. Posin of DePaul University on galaxies. Featured monthly is a rundown of astronomical meetings and television programs in the Chicago area. A six-month subscription for one dollar may be ordered from George Corso, 5306 S. Laflin, Chicago 9, Ill.

AAVSO SPRING MEETING

The American Association of Variable Star Observers has scheduled its annual spring meeting at the Adler Planetarium in Chicago, May 29-31. Sessions for papers, and the banquet, are set for Saturday the 30th. The two hosts for the meeting are the Chicago Astronomical Society and the Adler Planetarium, with program information available from the president of the society, Andrew A. Hay, 8024 Winnemac Ave., Chicago 31, Ill.

GREAT LAKES CONVENTION

Western Michigan University in Kalamazoo will provide the setting for the annual convention of the Great Lakes Region of the Astronomical League at the beginning of August. On the evening of July 31st there will be a welcoming program and a meeting of the regional council.

Further activities are planned for August 1st and 2nd. The Kalamazoo Amateur Astronomical Association is the host society. Program information is available from the regional chairman, Hans Baldauf, 1307 Warren Place, Kalamazoo, Mich.

Notes on the Denver Meeting

HEADQUARTERS for the Nationwide Amateur Astronomers Convention this August 28-31 will be the beautiful campus of the University of Denver. Sessions for papers and two banquets will be held in the modern Student Union building, where commercial and amateur exhibits are also to be set up.

Although housing will be at a premium because of the simultaneous Colorado "Rush to the Rockies" celebration, delegates to the meeting are assured comfortable accommodations in two new residence halls at the university. There is a total housing capacity of about 850 persons, and a cafeteria is within short walking distance in the union building.

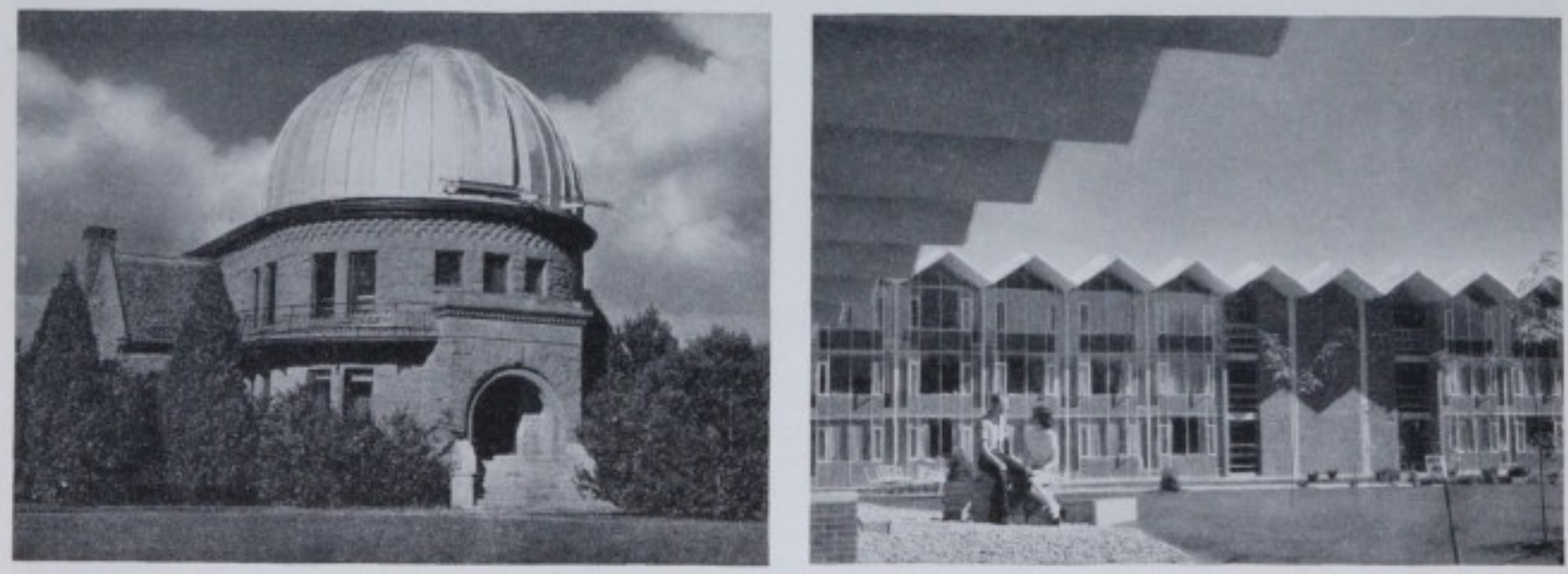
Single beds in two-bed rooms are available at $3.00 a day per person. For small families there are one-bedroom apartments, with an average of three beds per unit, at $7.00 per day. Two-bedroom apartments, accommodating five or six persons, cost $10.00 a day. Reservations should be made with Ned Onstott, 2421 Second Ave., Pueblo, Colo., who will also accept registrations and field-trip reservations.

On Sunday, August 30th, there will be an exhibit of amateur instruments and a star party on the lawn of the university's Chamberlin Observatory. The main telescope is a 20-inch Clark refractor that was displayed at the Chicago World's Fair in 1893. It has a visual focal length of about 26 feet, but if the crown element is reversed the instrument becomes a photographic refractor about three feet shorter in focus.

Chamberlin's first director, Dean Howe, used this instrument for discovering and charting about a thousand nebulae. Dr. Albert W. Recht has been director since Dr. Howe's death in 1926. He is an expert on comets.

There is ample space being set aside for the exhibit of exceptional amateur equipment. Information is available from the exhibit chairman, Henry D. Fiske, 2273 S. Fillmore St., Denver 10, Colo.

KEN STEINMETZ
1680 W. Hoye Place
Denver 23, Colo.



At the left is the University of Denver's Chamberlin Observatory, where a star party will be held during the nationwide amateurs meeting in Denver this summer. The 68-year-old building, made of red Colorado sandstone, houses a 20-inch Clark refractor. During the convention, delegates will stay in the university's new two-million-dollar residence halls (right). University of Denver photographs.

Finding the Age of the Earth

OTTO STRUVE, *Leuschner Observatory, University of California*

ALTHOUGH best known for his successful prediction of the return of a periodic comet, Edmond Halley studied a wide variety of scientific problems. In 1715 he suggested that the salinity of the oceans would indicate their age if the rate of addition of salt by rivers could be measured.

This method was applied in 1899 by John Joly, who estimated that the present oceans contain 1.5×10^{16} tons of sodium, which is a constituent of ordinary salt. In 1937, Arthur Holmes found that the present rate at which all the rivers of the earth are carrying sodium out to sea is 6×10^{7} tons per year. Dividing Joly's number by Holmes' gives 2.5×10^{8} years as an approximation to the age of the oceans.

There is, however, great uncertainty in this procedure, for today's rivers have not been in existence through all geological time, and the rate of sodium transport may have undergone large changes. Moreover, the age of the oceans is only a lower limit to that of the outer layers of the earth, which may have been a solid body over a much longer period.

Modern methods of determining the earth's age are mostly based upon measurements of the content in terrestrial rocks of the end products of various radioactive processes. A great deal of work in this field has been done in recent years by chemists, geophysicists, and astronomers. Here we shall discuss only some methods that utilize the radioactivity of uranium and thorium, whose atoms undergo very slow disintegration into several isotopes of lead.

For example, a uranium atom of atomic number 92 and atomic mass 238 ($_{92}U^{238}$) successively releases eight alpha particles (helium nuclei) to become lead of atomic number 82 and atomic weight 206 ($_{82}Pb^{206}$). Similarly, another isotope of uranium, U^{235}, loses seven alpha particles and decays to Pb^{207}. The disintegration of thorium ($_{90}Th^{232}$) follows a like pattern, forming Pb^{208}. In all three cases, the end products are lead and the gas helium.

There is excellent evidence that the rates of radioactive processes measured in the laboratory at the present time are valid also for the remote past. If a radioactive element and its decay products are imbedded in a crystal, each alpha particle emitted during disintegration travels a certain distance that depends only on the rate of that particular decay step. The more rapid this rate, the greater the energy of the alpha particles, and the farther they go before being stopped and producing a color change in the crystal.

Suppose a speck of U^{238} has remained undisturbed since the formation of a mineral containing it. Then, because the rate of disintegration at each successive alpha-particle emission is different, eight concentric rings of mineral discoloration will be found surrounding the particle of uranium. These rings, known as pleochroic halos, have been found in many rocks of different geological ages, and the diameters of the respective rings are always the same.

Thus, it can be concluded that the rates of disintegration of uranium and thorium are constant. This result agrees with theory: C. F. von Weizsäcker's calculations show that temperatures of the order of billions of degrees and pressures of several billion atmospheres are required to make the decay rates of these radioactive atoms appreciably different from their observed values.

Let us now consider a certain quantity, m_0, of U^{238} at time zero. In a short time interval, Δt, the amount has changed by $-\Delta m$, and this is proportional to the quantity of uranium present. We can therefore write: $\Delta m/\Delta t = -km$, where k is the *decay constant* of U^{238}. This formula implies that if we start at time zero with an amount m_0 at any future time t we shall have remaining

$$m = m_0 e^{-kt}.$$

Here e is the base of the natural logarithms and equals 2.718 . . . .

Instead of using the decay constant of a radioactive element, physicists more frequently refer to its half-life, T, the time required to reduce the radioactivity of the element to half its original value. In our example, T is the interval during which m_0 diminishes to $\frac{1}{2}m_0$. From the preceding formula, it follows that $T = 0.7/k$, approximately.

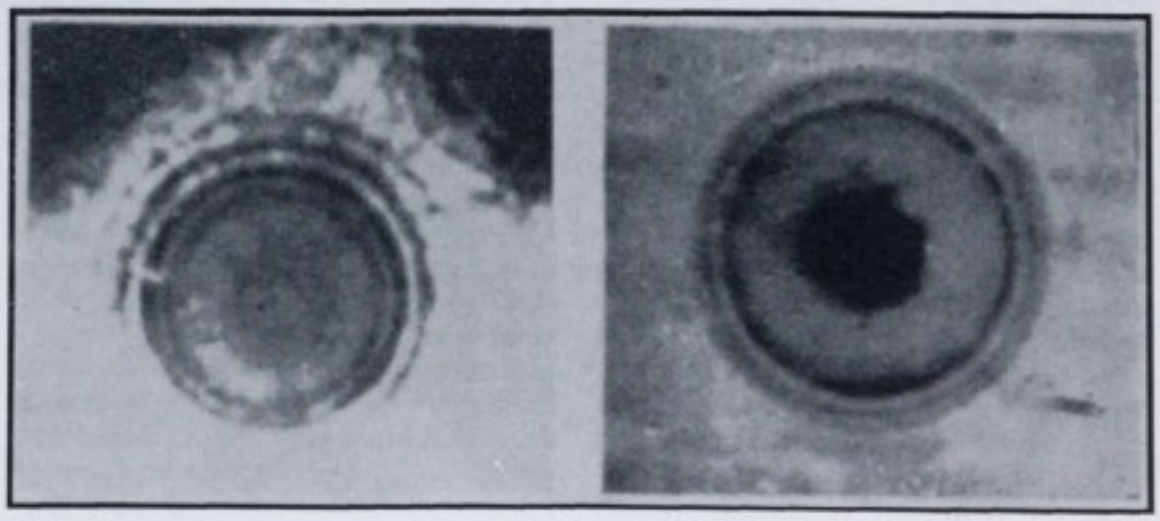
The half-life of uranium-238 is 4.5×10^{9}, or $4\frac{1}{2}$ billion, years. Of a sample of one million such atoms, 500,000 may be expected to exist after this lapse of time. For the uranium isotope of mass 235, the half-life is considerably less, 7.1×10^{8} years. In the long chain of successive disintegrations by which U^{238} becomes Pb^{206}, all the intermediate products have half-lives that are very small fractions of the half-life of the parent element. Consequently, to a close approximation the half-life for the chain as a whole can be taken as that for U^{238}, and the same argument applies to the decay series of U^{235} and of Th^{232}.

Suppose a mineral solidified some time

RADIOACTIVE DECAY OF URANIUM-238

Nucleus	*Particle Emitted*	*Half-Life*
$_{92}U^{238}$	α	4.50×10^{9} years
$_{90}Th^{234}$	β	24.1 days
$_{91}Pa^{234}$	β	1.18 minutes
$_{92}U^{234}$	α	2.50×10^{5} years
$_{90}Th^{230}$	α	8.0×10^{4} years
$_{88}Ra^{226}$	α	1,620 years
$_{86}Em^{222}$	α	3.82 days
$_{84}Po^{218}$	α	3.05 minutes
$_{82}Pb^{214}$	β	26.8 minutes
$_{83}Bi^{214}$	α	19.7 minutes
$_{81}Tl^{210}$	β	1.32 minutes
$_{82}Pb^{210}$	β	22 years
$_{83}Pb^{210}$	β	5.0 days
$_{84}Po^{210}$	α	138.3 days
$_{82}Pb^{206}$	Stable	——

Emission of an α-particle decreases the electric charge on the nucleus (subscript) by two and the mass number (superscript) by four. If a β-particle (negative electron) is emitted by the nucleus, the charge is increased by one, and the mass number is unchanged. In this list several branch reactions have been omitted. Adapted from Irving Kaplan, *Nuclear Physics*, Addison-Wesley Co., 1955.



These are greatly enlarged photographs of pleochroic halos in fluorite from Wölsendorf, Germany. At the center of each ring system is a minute speck of radioactive impurity, trapped there when the mineral was formed.

ago, containing U^{238} but no lead. Since then, lead has been built up slowly within the mineral, at the expense of uranium, and the ratio of the lead to the uranium must bear a fixed relation to the age of the mineral being analyzed. From the half-life of the uranium series, it follows that one million grams of uranium produce 1/7,600 gram of lead per year. Hence, the mineral's age can be calculated from the lead-uranium ratio:

$$\text{Age} = (Pb^{206}/U^{238}) \times 7.6 \times 10^9 \text{ years.}$$

In samples that are free of thorium, the U^{235} may be neglected in a first-order approximation, as the amount of it in any sample of uranium is small. Using the formula above for a specimen of Bohemian pitchblende from the Permian period, the sample's lead-uranium ratio being 0.03, gives an age of about 225 million years. When estimates such as this were first made several decades ago, they revolutionized our concepts of the age of the earth's crust and for the first time brought the geological time-scale into general agreement with astronomical ideas of the earth's age.

This picture is, however, greatly oversimplified, and the actual procedures of dating rock specimens have become more complicated as our knowledge has grown. For precise results, the U^{235} must be taken into consideration, thorium often is involved, and there are such problems as the escape of radon ($_{86}Em^{222}$) from the specimen, for radon is a gas. There is also the important alternative method of helium dating, this gas being the other end product of the radioactive decay processes. But since the possibility of helium escape always exists, this method can be counted on to give only minimum ages, and lead ratios are at present considered superior, particularly as a result of more recent work.

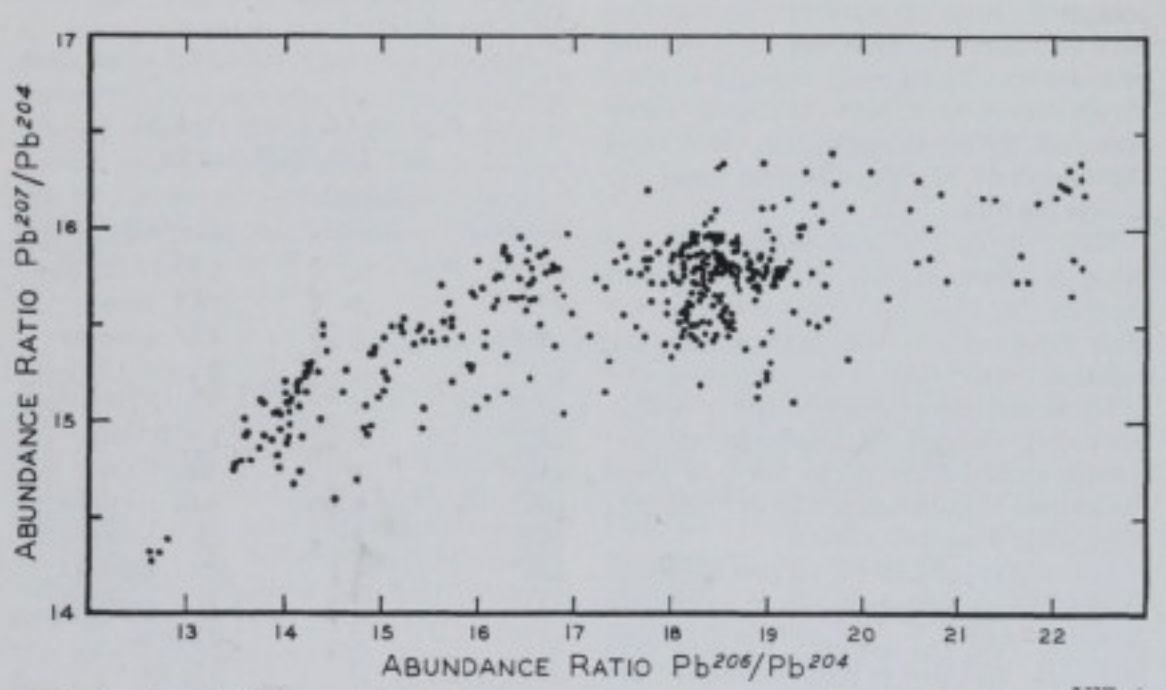
The newer methods make use of "ordinary" lead, that is, lead ores that are uncontaminated by uranium. More than 20 years ago, A. O. Nier developed a method of separating lead isotopes by means of a mass spectrograph, determining the relative amounts present of lead isotopes of atomic weights 204, 206, 207, and 208. The first of these, Pb^{204}, is less common than the other three, and does *not* result from radioactive decay.

Following the reasoning of A. Holmes and, more recently, of the Swiss scientist F. G. Houtermans, we assume that at an early stage in its history the earth was molten, and well mixed by convection currents. It contained Pb^{204} and, as a result of earlier radioactivity by uranium and thorium, unknown amounts of Pb^{206}, Pb^{207}, and Pb^{208}. When solidification of the crust took place, some rocks were formed that still contain the lead isotopes in their relative proportions at that time.

Meanwhile, as mixing of the molten magma beneath the crust continued, further uranium and thorium disintegration produced increasing amounts of their end products, but Pb^{204} remained unchanged. Younger igneous rocks than those formed with the crust came from this magma and thus should contain higher proportions of the decay isotopes — the larger the measured abundance ratios Pb^{206}/Pb^{204}, Pb^{207}/Pb^{204}, and Pb^{208}/Pb^{204}, the shorter the geological age of the rock being analyzed.

Many samples of lead ore contain no uranium, or exceedingly little. Since the disintegration of uranium proceeds very slowly — surely no more than 99 per cent of it could have disappeared through radioactive decay — we conclude that the uranium-free lead ores were essentially devoid of uranium when their rocks solidified. Therefore, their lead isotope ratios must be the same as when they were formed. A rock of great geological age — say a billion years — will contain relatively low amounts of Pb^{206} and Pb^{207}, only what was present in the magma that long ago. A younger rock, however, will have higher lead ratios, those of the magma, say, a few hundred thousand years ago.

This is actually the case, as Nier and others have found. In the accompanying diagram, the ratios Pb^{206}/Pb^{204} and Pb^{207}/Pb^{204} increase together, in confirmation of the reasoning above. The older rocks are at the lower left, the younger ones at the upper right. But these are relative ages that do not permit us to determine the absolute age of the earth's solid mantle as a whole.



Each dot in this diagram by F. G. Houtermans represents the results of chemical analysis of a lead-ore sample. The scale is much larger than that of the computed chart on the facing page.

Houtermans and others have proceeded along the following lines. Consider a rock sample in which the enrichment of Pb^{206} and Pb^{207} began at time $t = 0$, which we may identify with the epoch at which the rock solidified. A fraction of the original uranium has disintegrated and reappeared as lead and helium. The equations below express the relation between the present amounts of U^{238} and U^{235} and their decay products since $t = 0$. Allowance is made for any radiolead present when the rock solidified, and chemical symbols are used to represent the *amounts* of the respective elements.

$$U^{238}(e^{kt} - 1) = Pb^{206} + He^4 - \text{initial } Pb^{206}$$

$$U^{235}(e^{lt} - 1) = Pb^{207} + He^4 - \text{initial } Pb^{207}$$

Houtermans allowed for helium by a simple calculation, dropping He^4 from these equations. Then, dividing each expression by Pb^{204}, the nonradiogenic isotope, and dividing one expression by the other, he obtained:

$$\frac{U^{238}}{U^{235}}\left\{\frac{e^{kt} - 1}{e^{lt} - 1}\right\} = \frac{Pb^{206}/Pb^{204} - \text{initial } Pb^{206}/Pb^{204}}{Pb^{207}/Pb^{204} - \text{initial } Pb^{207}/Pb^{204}}.$$

What quantities in this expression are known? First, the ratio U^{238}/U^{235} refers to the present time, and is accurately known from measurements to be 139. That is, for every atom of U^{235} there are 139 of U^{238}. Next, analyses of lead ores that are now associated with uranium (or very recently were) show that Pb^{206}/Pb^{204} is 19.5, while Pb^{207}/Pb^{204} is 16.0. We also know k and l, the decay constants of the uranium isotopes.

Finally, a major breakthrough in this problem was achieved by Houtermans when he realized that for many iron meteorites the Pb^{206}/Pb^{204} ratio is 9.4, and Pb^{207}/Pb^{204} is 10.3. Both ratios are much smaller than any plotted in his diagram for the oldest surface rocks of the earth. He could then make the reasonable assumption that the meteorites were of great age and that their lead composition corresponds to that of the original molten earth. These numbers were therefore used for initial Pb^{206}/Pb^{204} and initial Pb^{207}/Pb^{204}, respectively, in the equation above.

The only unknown is t, for which the equation may be solved to give 4.5×10^9

years. This is the age of the earth computed by Houtermans and published by him in the German journal *Naturwissenschaften, 44,* 157, 1957. He estimated the uncertainty as $\pm 0.3 \times 10^9$ years.

Had we neglected the initial amounts of Pb^{206} and Pb^{207}, the value of t would have been overestimated as 5.0×10^9 years. It is only a coincidence that the age of the earth happens to be the same as the half-life of uranium 238. It merely shows that since the mantle of the earth became solid about one half of the original U^{238} in it has had time to disintegrate.

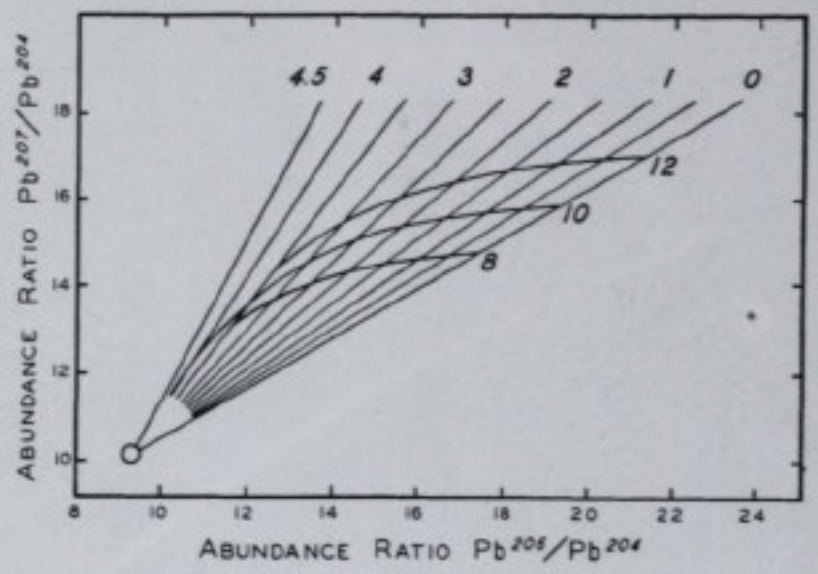
Once having established a good value for the earth's age, Houtermans was able to calibrate the lead-ratio measurements of rocks that are free of uranium contamination. Suppose that the uranium disintegration proceeded from 4.5×10^9 years ago until one billion years ago, and that at this time a lead ore formed that was completely free of uranium. For such a case, Houtermans computes a set of pairs of values of Pb^{206}/Pb^{204} and Pb^{207}/Pb^{204}, corresponding to different ratios of U^{238}/Pb^{204} in the original medium. The resulting points, when plotted in the accompanying chart by Houtermans, fall on a straight line, labeled 1 at the top. For still older uranium-free ores we obtain the rest of the straight lines, labeled in billions of years to the left of zero, which corresponds to the present time.

Points on these diagonal lines that correspond to identical values of the ratio U^{238}/Pb^{204} are joined by curved lines, and comparison with Houtermans' plot of observed values (on page 434) shows that the terrestrial rocks all have ratios between eight and 11.

An ore that had no uranium in it during the past 2×10^9 years, but was previously characterized by a ratio of 10 between U^{238} and Pb^{204}, would lie on the intersection of the middle of the three curves and the straight line labeled 2. As a Bern University professor, Houtermans has called this chart a "Bern-graph," and it is very useful for geologists who wish to date various lead ores independently of purely geological methods.

The precise significance of the age of the earth has recently been discussed in an article by J. T. Wilson, R. D. Russell, and R. M. Farquhar, "Radioactivity and Age of Minerals," which appeared in the *Handbuch der Physik, 47,* 334, 1956.

"The physical event to which the 'age of the earth (t_0)' refers deserves serious consideration. All the calculations assume that there is a time t_0 prior to which the lead, uranium, and thorium isotopes were distributed uniformly (with respect to lead-204) throughout the material of the earth. At time t_0 some process of differentiation produced variations in the concentrations of the uranium and thorium isotopes with respect to lead-204, but none in the lead isotopes. This is a reasonable assumption, since the ratios of the lead isotopes to one another would not be affected by natural chemical processes, whereas uranium and thorium have different properties from lead and therefore variations from place to place may well have been produced in their concentrations with respect to lead-204. If the earth had a molten origin, t_0 would be practically the same as the time of solidification of the entire earth, since the latter process would be quite rapid. If the earth was formed by accretion of solid particles, it may have become molten and then solidified again, or it may have had a still more complicated history, but t_0 would still represent the time when the upper part of the earth's mantle became stable. At the time Holmes first wrote it was generally believed that the continents had formed at the same time as the earth solidified and he therefore called t_0 'the age of the crust.' In view of recent theories that the continents probably have grown during geologic time, it seems wiser to call t_0 'the age of the upper mantle.' If ores have, in general, a deep-seated origin, this is certainly what t_0 represents."



Professor Houtermans has computed this graph for finding the ages of lead ores. The circle at the lower left represents iron meteorites which are presumably of great age. The straight lines are labeled in billions of years. Both diagrams with this article are from "Naturwissenschaften," published in Germany.

STAR VISIBILITY BY DAY AT HIGH ALTITUDES

Although several manned balloons have recently reached great heights (16 to 19 miles), balloonists have not reported seeing the stars in the daytime. Yet they describe the sky as very dark. M. J. Koomen, of the Naval Research Laboratory, believes this impression of darkness is at least partly due to contrast with the bright clouds below and the strongly illuminated balloon above. In addition, the small viewing ports of the gondolas may restrict the observers' view for star sightings.

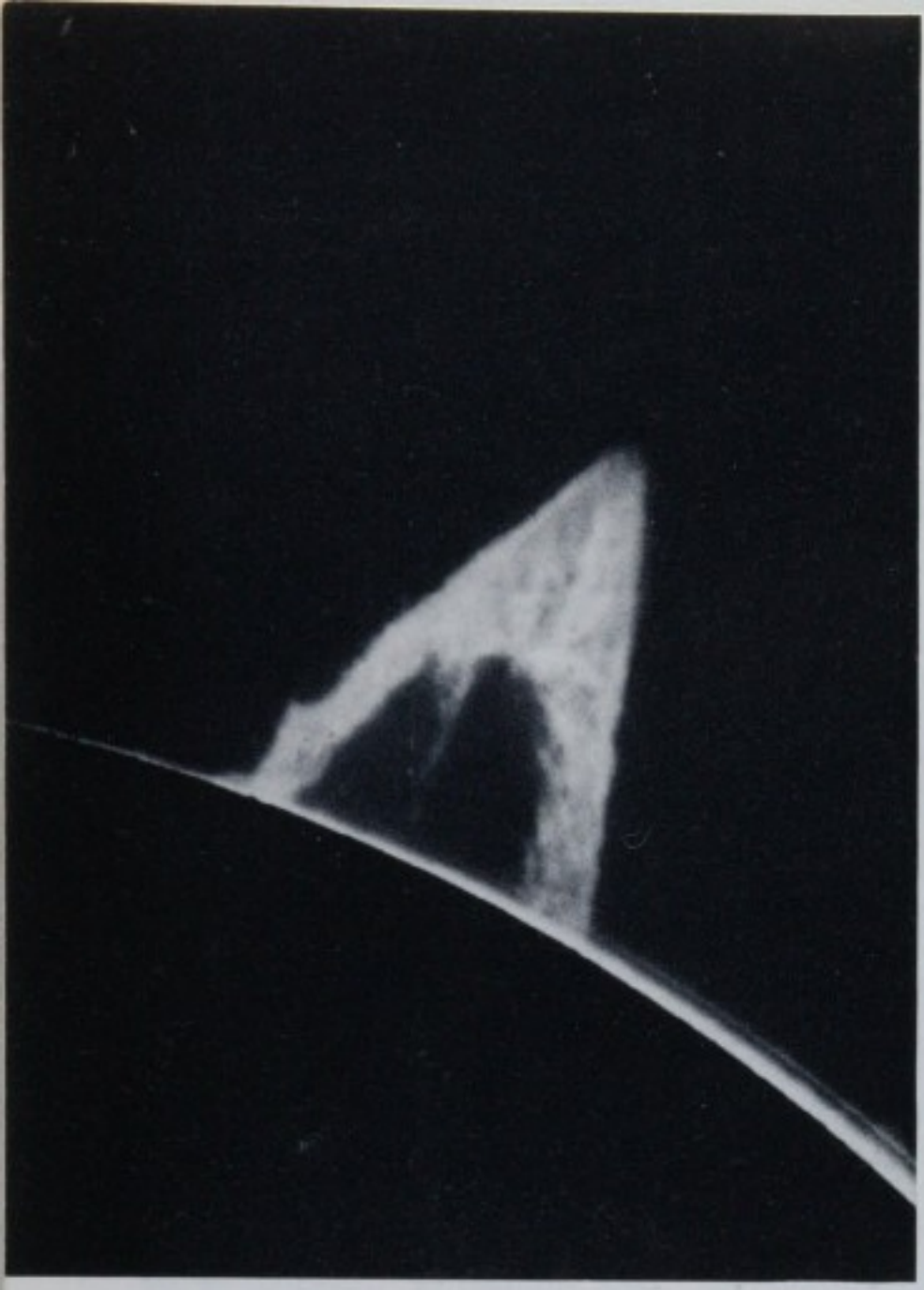
Dr. Koomen's calculations show that at 100,000 feet elevation the brightness of most of the sky is like that seen by a sea-level observer when the sun is only three degrees below the horizon. He bases this result partly on known sky luminances at 10,000 feet, reduced in proportion to the lower barometric pressure at 100,000 feet. This relation of sky brightness and atmospheric pressure is indicated by the work of D. M. Packer and C. Lock, as well as by photometric measurements made from the stratosphere balloon Explorer II in 1935, when it rose to some 72,000 feet. In October, 1957, M. D. Ross made measurements at 85,400 feet that are in substantial agreement with the predictions.

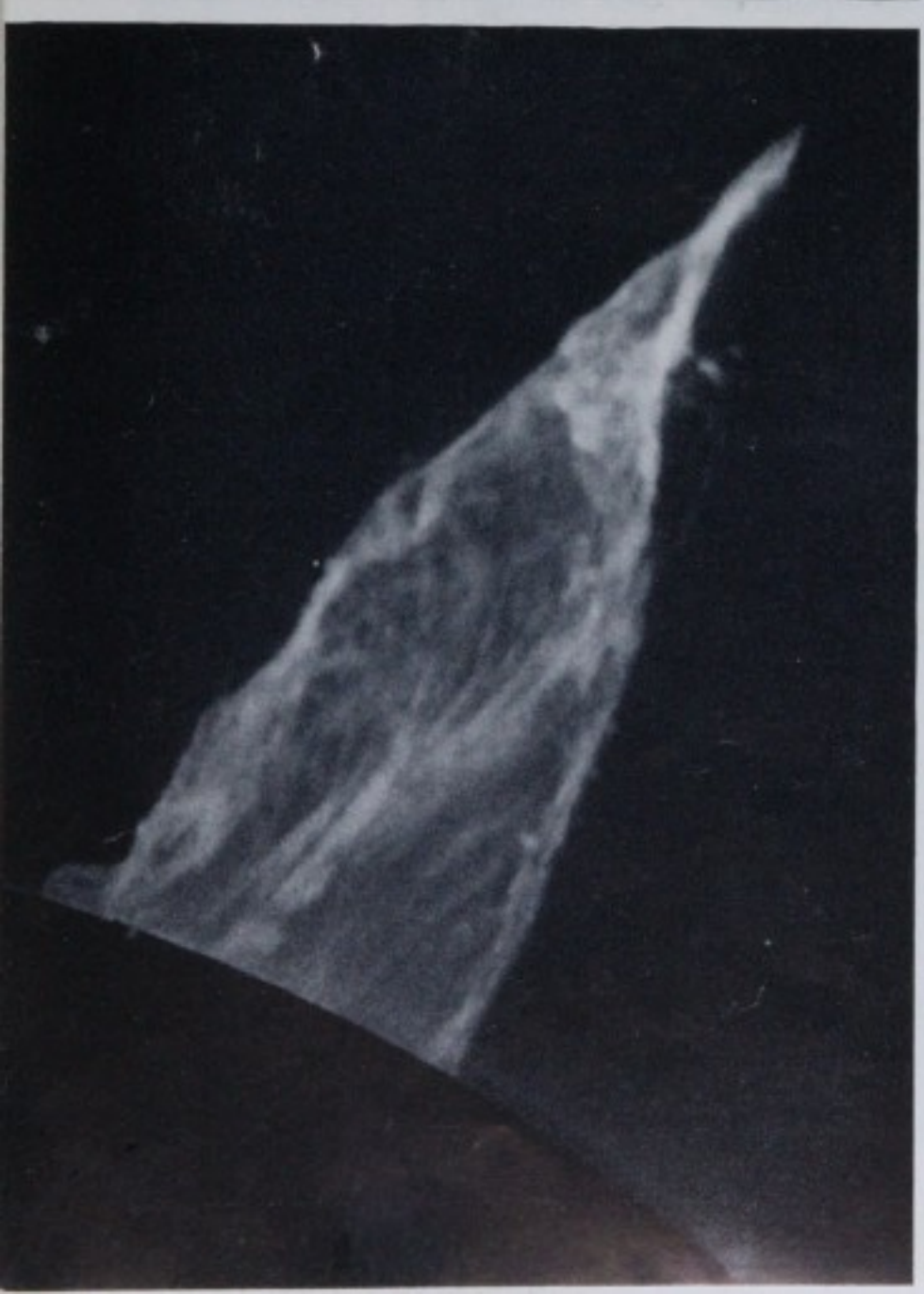
If an observer at 100,000 feet knew *exactly* where to look, stars as faint as magnitude +1.3 could just be discerned in the darkest part of the sky. But the practical threshold would be between −1.4 and −0.2, depending on the altitude of the sun and the part of the sky involved. Hence the planets Venus, Jupiter, and sometimes Mars, should be observable, and the stars Sirius and Canopus, if the observer's gaze should come within two or three degrees of one of them.

The details of Dr. Koomen's study have been submitted for publication in the *Journal* of the Optical Society of America. He has constructed a graph showing the states of twilight at sea level that match the brightness of the daytime sky at various altitudes above the surface of the earth. Based on his graph, the following table gives the threshold stellar magnitude in the zenith for each height, when the sun is 35 degrees above the horizon. The third column states how many degrees the sun must be below the horizon of a sea-level observer for the zenith sky to be equally dark. The last column, calculated for an observer on the ground in latitude 40° north, gives how many minutes he should wait after a mid-June sunset for the sun to become that low. This will enable the reader to judge firsthand the probable appearance of the daytime sky at great heights.

It is evident that the high-altitude observer will not experience the darkness and star visibility characteristic of the night sky until he is above 100 kilometers, or more than 60 miles.

Height in Kilometers	*Faintest Magnitude*	*Sun Below Horizon*	*Minutes After Sunset*
30	+1.1	3°.2	15
40	+1.9	4°.3	21
50	+2.6	5°.3	28
60	+3.2	6°.2	34
70	+3.8	7°.3	40
80	+4.5	9°.0	52
90	+5.0	11°.2	68
100	+5.6	15°.3	100





NEWS NOTES

COLOR PHOTOGRAPHS OF DEEP-SKY WONDERS

At Mount Wilson and Palomar Observatories, William C. Miller has used the 200-inch Hale reflector and the 48-inch Schmidt camera to take color photographs of nebulae and galaxies with unprecedented success. Reproductions of six of these pictures appeared in the May issue of the *National Geographic Magazine* and in *Life* for April 27, 1959. They show the great Andromeda galaxy, and the Ring, Crab, Orion, Veil, and North America nebulae in unfamiliar but strikingly beautiful form. The Ring nebula has a crimson rim, shading inward through yellow to a greenish blue interior!

Mr. Miller points out that his pictures required the combined speed of the new Super Anscochrome color film and the largest optical telescopes in the world. But in such cases as the Crab nebula, where nearly five hours of exposure were required, the multilayered emulsion could not render true relative color values. It was necessary to make corrected copies, filtering out two-thirds of the blue and a fifth of the green, while the red remained unchanged. The intricate color-correction process was achieved after two years of experiments in co-operation with Ansco engineers.

Color printing, however, cannot provide the same fidelity of hues as a carefully made transparency, which should be used for scientific studies. The pictures will shortly become available for sale by the California Institute of Technology Bookstore, 1201 E. California St., Pasadena 4, Calif., in the following forms: 2-by-2-inch and 3¼-by-4 slides, type-C color prints from 8 by 10 to 16 by 20, and transparencies from 5 by 7 inches to 20 by 24. Orders will probably require two months to be filled.

APRIL ERUPTIVE PROMINENCE OBSERVED IN CZECHOSLOVAKIA

Solar observatories around the world keep a 24-hour vigil on our nearest star, using a wide variety of instruments. Striking flares on the surface of the sun, and the prominences at its limb, are recorded with spectroheliographs, coronagraphs, and other devices.

On the 11th of April, 1959, during the predawn hours for astronomers in the United States, the prominence pictured opposite erupted from the sun's southwest limb. But it was daylight in Czechoslovakia, and Joseph Klepesta, at the Popular Observatory in Prague, obtained this series of photographs with the 6.3-inch f/18.5 coronagraph. The observations were made in red hydrogen-alpha light, isolated by a quartz monochromator with a five-angstrom passband. He writes:

"Two days earlier, this prominence was a quiescent one. On the morning of the 11th it became active, developing a filamentary structure which quickly became surprisingly bright. At 9:01 Universal time, when the first picture was taken (upper left), a bright arch was observed, increasing rapidly in height to 224,000 miles (upper right). Unfortunately, intermittent clouds interrupted my observations, but delicate streams of gas were seen extending up to more than half a million miles from the sun's surface. Visually, I could follow a great looped formation on top of the prominence, expanding with a speed of 250 to 300 miles per second.

"My last picture was taken at 9:49 UT, but fails to show the outer parts of the eruption. In reality, the whole protuberance was a great arch, its plane lying in the line of sight and not across it, unlike the great arch prominence observed at Climax, Colorado, in June, 1946 (SKY AND TELESCOPE, August, 1946, page 11)."

FACING PICTURES: On April 11, 1959, in the morning for European observers, this gigantic eruption occurred at the edge of the sun. At Prague, Joseph Klepesta obtained these four pictures. He gives their Universal times as 9:01, 9:11, 9:45, and 9:49. He used the 6.3-inch coronagraph of the Popular Observatory, with a monochromator passing only red hydrogen light. Each exposure was half a second on Agfa Super film.

AN ULTRAVIOLET TELESCOPE IN A SATELLITE

Although high-altitude rocket flights have already contributed important data concerning celestial objects in hitherto inaccessible ultraviolet regions of the spectrum (page 369, May issue), some astronomical problems can only be solved by sustained observations from a high-flying satellite. A proposal to place an astronomical telescope in a satellite has been made by R. J. Davis, R. E. McCrosky, F. L. Whipple, and C. A. Whitney, all of the Smithsonian Astrophysical and Harvard observatories.

They suggest launching an off-axis telescope with an 8-inch f/3 mirror, and employing a specialized television image tube at the focus. The spectral response would be limited by filters to four bands in the region between 1050 and 3000 angstroms. The output of the television tube would be telemetered to the ground, providing a picture of a small part of the sky.

To keep star images from blurring, the telescope's optical axis must drift less than 20 degrees per hour, even if each scan of the television field requires only one second. Therefore, the satellite would employ jets of gas to eliminate the angular momentum remaining from the launching process, and the telescope mounting would have to be carefully balanced to reduce the earth's tidal torque to a minimum. In addition, three sets of small flywheels operated by motors would shift the telescope from one part of the sky to another.

Every attempt must be made to keep the satellite and its instrument as simple as possible without seriously limiting its potentialities for astronomical research. It is hoped to obtain sensitivity and resolution that will record a minimum average of 10 stars per square degree, with an angular resolution better than one minute of arc. Exposures of from one to 10 seconds will be needed to record 10th-magnitude stars.

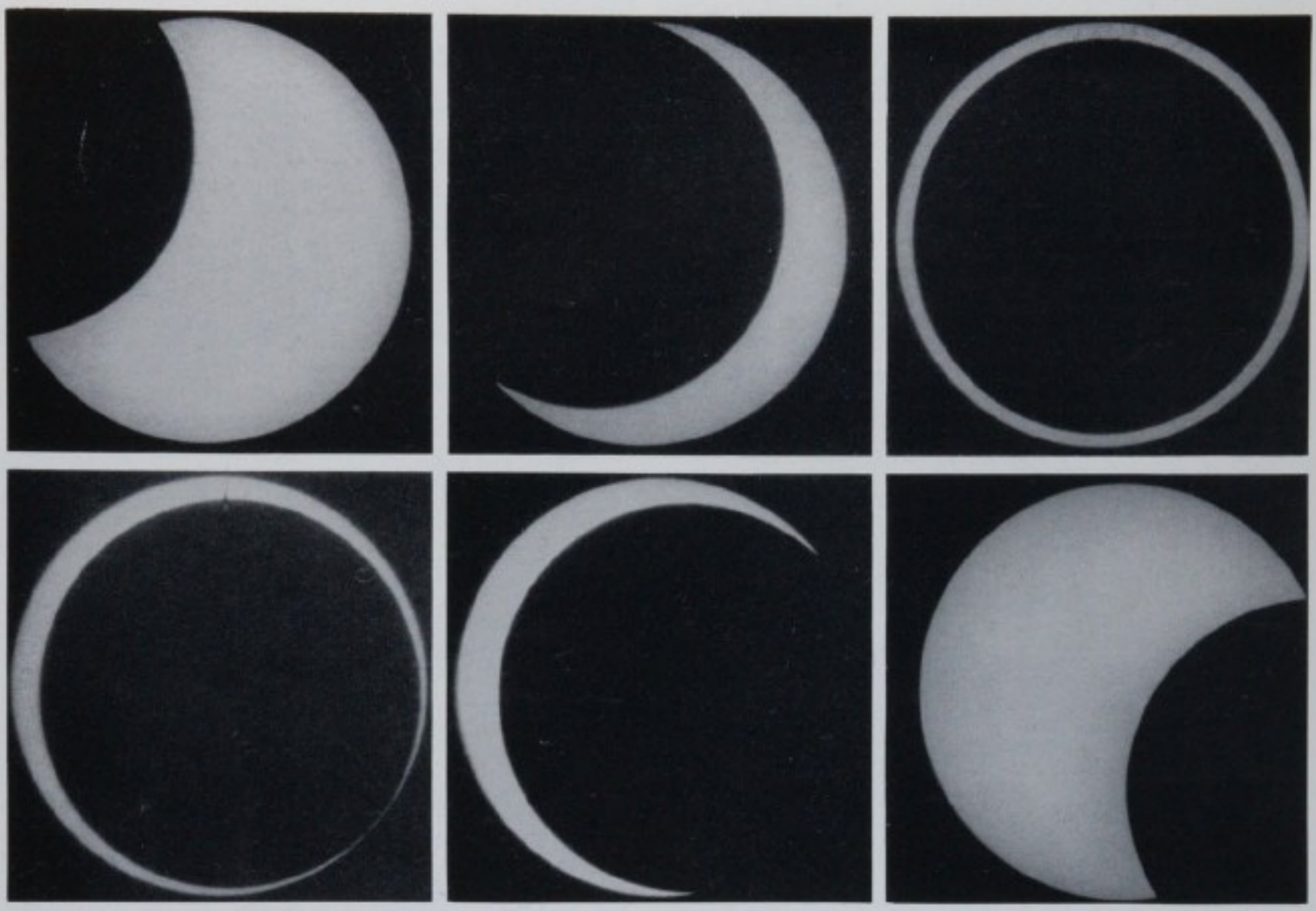
A satellite flying 500 miles high at latitude 20° north can observe the entire celestial sphere, as from that height the south celestial pole is seven degrees above the apparent horizon. At least two ground stations, situated about 2,000 miles apart and with rather complex controls, would be required to enable the satellite telescope to function most efficiently. If the average total observing time for two stations within the United States were two hours per day, slightly over 300 days would be required to map the entire sky in the four selected spectral regions.

IN THE CURRENT JOURNALS

METHODS FOR PREDICTING THE ORBITS OF NEAR EARTH-SATELLITES, by D. G. King-Hele and Mrs. D. M. C. Walker, *Journal* of the British Interplanetary Society, January-February, 1959. "Using the methods described in this article, one person with a desk calculating machine can undertake prediction for two or three satellites. The methods are most suitable for the satellites which are most difficult to predict, those with life-times of less than one year."

ROCK MAGNETISM, by S. K. Runcorn, *Science*, April 17, 1959. "The evidence of paleomagnetism, with which that of paleoclimates does not conflict, suggests that the poles of rotation of the earth and the land masses have gradually changed their relative positions."

POLYNESIAN NAVIGATIONAL STONES, by Capt. Brett Hilder, *Navigation*, Winter, 1959. "The navigational stones of Arorae [Gilbert Islands] can be assumed to have been erected and aligned after the courses to steer by the stars had become traditional. They were therefore *aides-memoire*, or sailing directions, used in the Polynesian lore of navigation as well as being used to set departure courses from a standard 'starting point.' These stones, particularly the ones erected in pairs, may be regarded as the highest level of precision reached in canoe-voyaging in the Pacific, about 1500 A.D."



The annular eclipse of April 8, 1959, photographed by Ronald W. Boggis, Perth, Australia, at the Universal times (upper left to lower right): 1:20:03.5; 2:00:08.7; 2:13:05.0; 2:16:01.0; 2:20:05.3; and 3:10:06.6. South is upward.

APRIL'S ANNULAR ECLIPSE IN AUSTRALIA

B. J. HARRIS, *Perth Observatory, Western Australia*

IN WESTERN AUSTRALIA, where the annular phase of the eclipse of the sun on April 8, 1959, lasted about 6½ minutes, visual observations and photographs were successfully made by many persons. At Perth Observatory, within the path of the annular eclipse, we used a 12-inch refractor for photoelectric observations of the limb darkening close to the edge of the sun.

The eclipse pictures above were taken by Mr. Boggis with the help of his wife, who is here recording data while he operates his theodolite-camera arrangement. The projected sun's image was 1.6 inches in diameter, and the exposures were 1/75 second on Kodak Verichrome Pan film, with green and very dense neutral filters. The observing site was the Perth Moonwatch station, of which Mr. Boggis is team leader. It is located at longitude 115° 51′.2 east, latitude 32° 00′.1 south.

The series of pictures obtained by Mr. and Mrs. Ronald W. Boggis is, I think, the best of the amateur results. He has mounted them to show the successive stages of the eclipse, beginning with the moon taking a large "bite" out of the sun. His photograph of the annular phase shows the moon almost perfectly centered on the sun. The annulus is very wide, as the moon was nearly at apogee, with its apparent radius much less than that of the sun. At Perth the magnitude of the eclipse was 94 per cent, that is, six per cent of the sun's diameter remained uncovered.

Mr. Boggis set up his theodolite at an angle of 32 degrees, so that the azimuth axis served as a polar axis. The optical train consisted of a 40-mm. objective, eyepiece, shutter, green filter, neutral filter, and film, the lens of his camera having been removed. Projection onto a

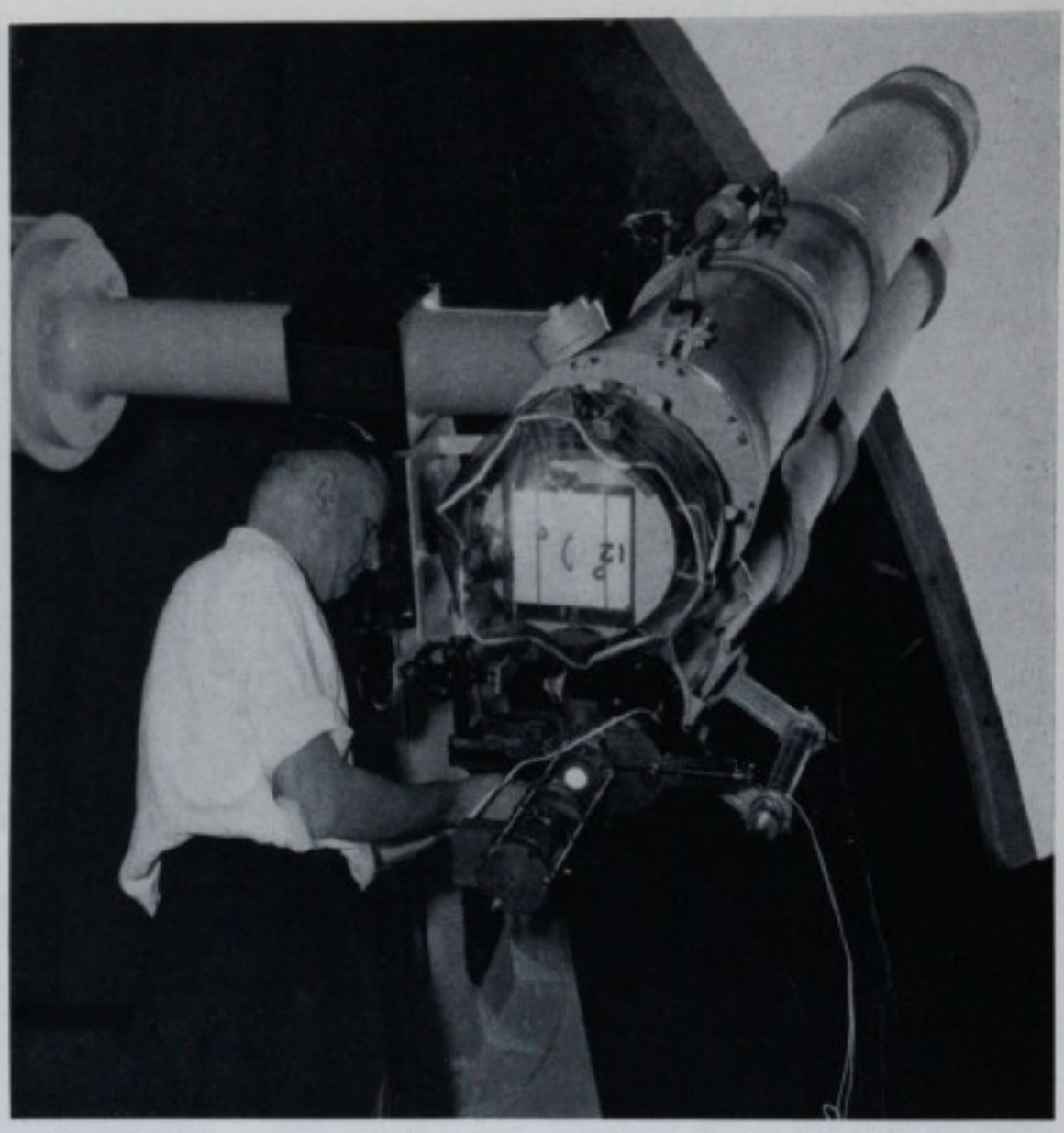
grid-marked screen served for guiding. For timekeeping Mrs. Boggis used stop watches and radio time signals.

Frank Leroux worked with Mr. and Mrs. Boggis. He attached a folding camera to a 1-inch theodolite, the system being effectively f/34. With a neutral filter, exposures of 1/100 second on Adox fine-grain film gave satisfactory results.

P. Norris and A. Strickland used an 11-cm. achromatic refractor, stopped down to eight centimeters, with a focal length of 120 centimeters. They attached a camera to the eyepiece, which projected a solar image nearly 3½ inches in diameter. Other photographs were taken by Tony Forte, using a theodolite and 1/100-second exposures.

At the Perth Observatory, I worked with Dr. S. E. Williams and G. Rooke of the physics department of the University of Western Australia. We attached a photomultiplier tube to the 12-inch visual component of our astrographic telescope, and during the annular phase the light intensity in a narrow green band was recorded, allowing us to determine the solar limb darkening, the moon acting as a kind of cosmic shutter.

In the picture of our setup, the image of the sun can be seen on an opal glass screen placed at the focus, the 12-inch objective being stopped down to two inches. In front of the screen is a diaphragm. Below that is a holder for a neutral filter of 12-per-cent transmission, then the color filter, and finally a collimating lens, which produced a 10-mm. image on the screen of the photomultiplier. This tube is in the wooden box at the end of the attachment.



At Perth Observatory, final adjustments are made to the photoelectric apparatus before it is placed inside a light-tight cover. Above the 12-inch visual refractor is a standard 13-inch astrograph, with a plastic cover protecting the Markowitz moon-position camera that occupies the normal plateholder position. Photograph courtesy Western Australia Newspapers, Ltd.

QUESTIONS... FROM THE S+T MAILBAG

Q. What is the brightness of the moon at full and at first and last quarters?

A. The full moon is magnitude −12.74; first quarter, −10.03; and last quarter, −9.97. These are magnitudes on the Harvard visual system, derived photoelectrically by G. Rougier.

Q. Why are most astronomical photographs published with south, rather than north, at the top?

A. This is done so that the orientation of the picture will correspond to the view in an astronomical (inverting) telescope in the Northern Hemisphere.

Q. How is the light-gathering power of a telescope calculated?

A. The dark-adapted unaided eye is taken as the standard. As its pupil diameter is about ¼ inch, the light-gathering power is $L = 9a^2$, where a is the telescope aperture in inches. Thus, for a 3-inch telescope, $L = 81$. This represents a gain of about 4½ magnitudes, so a 3-inch instrument should show stars of magnitude 10½ on a clear, dark night. However, light losses in the telescope reduce the light-gathering power, usually by 10 or 15 per cent, but sometimes much more.

Q. What is meant by small, medium, and large telescopes?

A. As a rough rule, amateur reflectors of 4-inch aperture or less are called small; from about six to 10 inches, medium; and 12 to 16 inches, large. For refractors used by amateurs, these figures are approximately three inches or less, four to six inches, and seven to about 10 inches.

Q. Is the "old moon in the new moon's arms" seen at every lunation?

A. Yes, though it is often masked by local conditions such as haze or artificial lights. Its visibility depends greatly upon the observer's visual acuity — some persons have reported seeing the dark portion even when the moon is gibbous.

Q. What is meant by the geocentric time of the conjunction of the moon with a planet?

A. This is the time at which the closest approach of the two bodies would be seen from the center of the earth, or by an observer on the surface witnessing the event in his zenith. Elsewhere on the earth's surface, the observed time may differ by up to about two hours from the geocentric time. W. E. S.

CORNELL APPOINTMENT

An expansion of astronomical teaching and research at Cornell University in the fields of radio astronomy and astrophysics will be effected under the guidance of Thomas Gold, who will become chairman of the department of astronomy on July 1st. He is also to be director of radio astronomy and a professor of electrical engineering.

Professor Gold is well known for his theories of continuous creation of matter, cosmic ray origin, dust on the moon, and polar wandering. Formerly chief assistant at Greenwich Observatory, he has been on the staff of Harvard Observatory for the past 2½ years.

A.S.P. JUNE MEETING

The Astronomical Society of the Pacific will hold its summer meeting on June 17-19 at the California Academy of Sciences in San Francisco. In addition to sessions for papers, there will be a symposium on astronomy in space science and a demonstration at the Morrison Planetarium. Further information may be obtained from George W. Bunton, California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 102nd meeting of the American Astronomical Society at Rochester, New York, in March, 1959. Complete abstracts will appear in the Astronomical Journal.

Artificial Meteor Observations

On the night of October 16, 1957, an Aerobee rocket about 50 miles above New Mexico fired two shaped charges, discharging high-speed particles of aluminum into the atmosphere in order to simulate meteor phenomena (SKY AND TELESCOPE, January, 1958, page 111). A third shaped charge, of a coruscative material, was also flown.

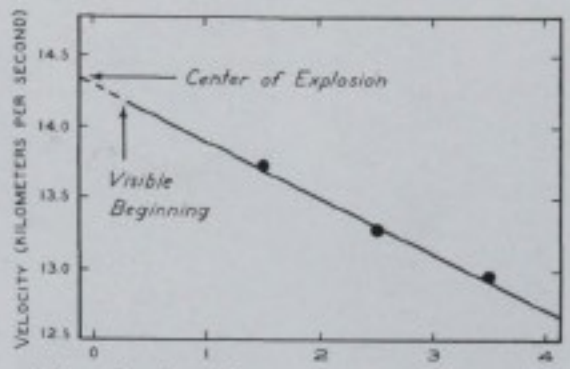
Richard E. McCrosky, Harvard Observatory, reported the results of photographic observations planned at five stations on or near the rocket firing range. The Harvard meteor stations at Sacramento Peak and Organ Pass each had a pair of super-Schmidt meteor cameras. The other three stations were manned by physicists from New Mexico State University, who used small ballistic-tracking cameras.

Each instrument of the latter type obtained good photographs of the brilliant explosion that occurred as the charges were fired and of two artificial meteors emanating from it. One of these had a shorter trail than the other. For Sacramento Peak, however, the long trail overlapped the short one, so only the former is apparent on the film. Clouds spoiled the observations at Organ Pass.

Using all available films from these cameras, Dr. McCrosky determined the trajectories of the artificial meteors by the same methods of triangulation that are applied to photographs of natural meteors. One of the Sacramento Peak super-Schmidts had a rotating shutter, which impressed time breaks on the long meteor trail, making it possible to measure the meteor's velocity and to show that it underwent a marked deceleration by the atmosphere.

On the assumption that the deceleration was constant over the 0.95-kilometer-long path, Dr. McCrosky calculated that the initial velocity of the body was 14.4 kilometers per second at the center of the explosion. The meteor lasted for 0.07 second and was at an altitude of 79.2 kilometers above sea level.

The particles producing this particular meteor came from the aluminum liner of a shaped charge three inches long and half an inch in diameter. The wall thickness was 0.28 inch, and the total liner mass about 5.5 grams. In tests of explosions of similar charges, carried out at Poulter Laboratories, Stanford Research Institute, the maximum velocity obtained was 14 kilometers per second, in close agreement with the observational result given above. However, the laboratory fragments reaching this speed were of the order of five microns in diameter or smaller; larger particles were produced but with lower velocities. Only a few per cent of the total liner mass was expelled at speeds greater than 10 kilometers per second, according to the laboratory experiments.



The slowing down of an artificial meteor during its 0.07-second visibility, deduced from measurements of a Sacramento Peak film. The horizontal scale marks shutter breaks, occurring 60 times a second. Harvard Observatory diagram by R. E. McCrosky.

From the observed deceleration, Dr. McCrosky has made a second but very uncertain estimate of the average particle size as about 24 microns. In either case, the small size assures that the meteor was stopped by the earth's atmosphere and could not have escaped into interplanetary space.

UV Ceti

Since 1947, the flare star UV Ceti has been known as a stellar object of exceptional interest. Only 8½ light-years distant, it is a visual binary composed of two red dwarfs with spectral type d*M*5.5e and magnitudes 12.5 and 13.0. These are among the least massive stars known.

P. van de Kamp, director of Sproul Observatory, reported on photographic observations made since 1949 with the Swarthmore College 24-inch refractor. Because this southern star could be observed only at low altitudes, photographs generally gave a blended image. During the last few years, however, the separation between the two components has markedly increased, so the pair is occasionally well resolved on plates taken during good seeing. The growing separation has been confirmed by G. Van Biesbroeck's visual measurements with the McDonald Observatory 82-inch reflector.

Since discovery, the secondary star has completed only about a quarter of an orbital revolution, so any orbit calculation is still rather uncertain. Dr. van de Kamp finds the companion moving in a markedly elongated ellipse, in a period now estimated at about 200 years. Earlier it had been believed that the orbit was nearly circular, with a period of some 32 years. The new calculations show that passage of the secondary through periastron occurred in 1948.

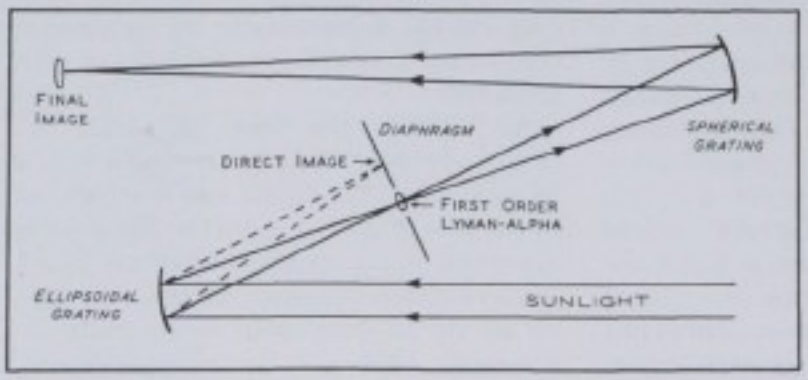
Dr. van de Kamp's measurements indicate that the parallax of UV Ceti (also known as Luyten 726-8) is 0.38 second of arc, corresponding to a distance of 8.6 light-years. The sum of the masses of the components turns out to be 0.08 times the sun's mass, in good agreement with earlier, tentative findings (see SKY AND TELESCOPE, May, 1956, page 299). The Sproul observations suggest that the two stars do not differ greatly in mass.

Solar Photographs in Lyman-Alpha Light

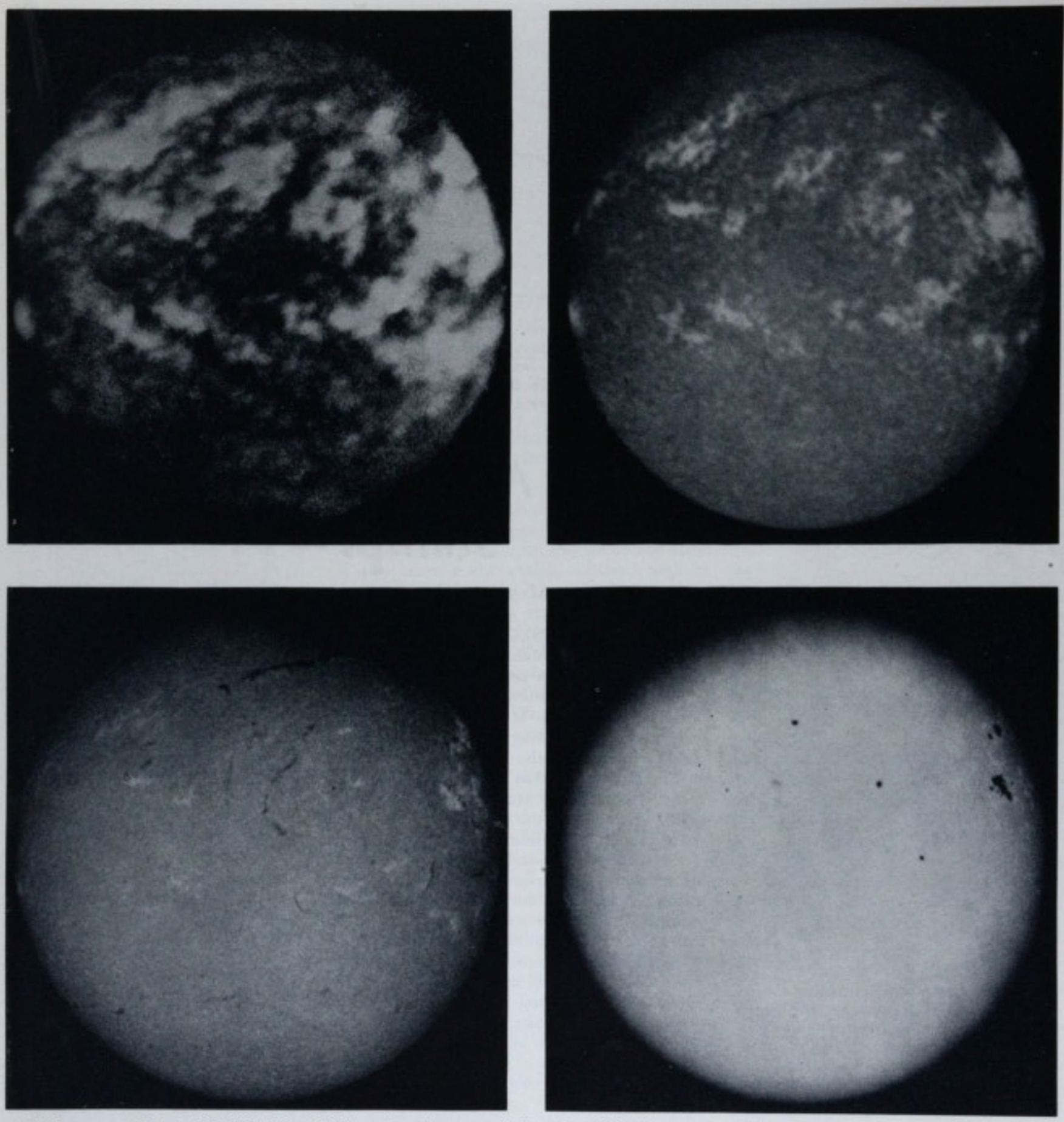
The red hydrogen-alpha line is the first in the Balmer series in the visible region of the spectrum. In the far ultraviolet there is another hydrogen series, named for Lyman and having its first line at 1216 angstroms — the Lyman-alpha line. The sun radiates strongly at this wave length, and for many years rocket scientists have been striving to photograph the sun to see how its appearance in Lyman-alpha light compares with that in hydrogen-alpha and in white light.

On March 13, 1959, Naval Research Laboratory scientists successfully flew a Lyman-alpha camera in an Aerobee-Hi rocket above White Sands Proving Ground, obtaining the first detailed rendition of the solar chromosphere in the far ultraviolet. These new observations were reported by R. M. Tousey, J. D. Purcell, D. M. Packer, and W. R. Hunter.

Previous experiments had been carried out by W. A. Rense and others using filters and lithium-fluoride optics to isolate



The optical system used in rocket photography of the sun in Lyman-alpha light. The diaphragm between the gratings screens off light of unwanted wave lengths. Naval Research Laboratory diagram.



The sun on March 13, 1959. The NRL rocket photograph (far ultraviolet) is at upper left, and a McMath-Hulbert spectroheliogram in violet calcium light at upper right. The NRL photograph at lower left is in hydrogen-alpha (red) light, while the white light picture, with sunspots, is from the U. S. Naval Observatory. Photos courtesy Naval Research Laboratory.

the desired wave lengths, yielding coarser pictures (SKY AND TELESCOPE, August, 1958, page 502). The new pictures, however, were taken with two highly reflecting gratings, using an optical system of a type proposed by University of Colorado physicists and described in the *Journal* of the Optical Society of America in March, 1954.

Light from the sun is formed into a spectrum by the first grating, and a diaphragm is placed to pass only the bright image at 1216 angstroms. A second grating then recombines the light and focuses it on the photographic plate. In order to prevent astigmatism in the first-order 3.6-millimeter image, the first grating was ruled on an ellipsoidal concave surface. The second grating was spherical.

The pictures were taken at an altitude of about 123 miles, some 60 exposures being made with durations from 1/200 second to seven seconds. The best results were obtained with the shortest exposures.

Simultaneous photographs in white light, the violet K line of ionized calcium, and hydrogen-alpha light, were made at ground stations. One of each is shown here for comparison with the sun's Lyman-alpha appearance. The association of bright regions with visible sunspot areas is quite evident, while a dark filament in hydrogen-alpha and calcium light appears as a fairly dark strip in the rocket picture.

This new method of photographing the sun in ultraviolet light above the earth's atmosphere should greatly advance our knowledge of solar-terrestrial phenomena, for Lyman-alpha radiation has long been suspected of affecting the earth's ionosphere and causing changes in weather patterns.

An artist's conception of the "Mechta" rocket appears on this blue-and-brown Bulgarian air postal. The payload attained a solar orbit with a period of about 450 days.

The instrumented sphere of Russia's "Mechta" space probe is shown in orbit with other members of the solar system on this 60-filler ocher and Prussian blue commemorative issued by Hungary shortly after the launching early in January. Besides the probe itself, representations of the moon, the earth, Jupiter, and Saturn can be identified.

Some Astronomical Stamps—VI

ALPHONSE P. MAYERNIK

THESE FINAL SELECTIONS from my astronomical postals illustrate further the collection's wide variety of pictorial themes, ranging from prehistoric solar designs to 1959's artificial planetoids. Most of these stamps are very recent, indicating a rapidly broadening field of interest for the astronomical philatelist.

Three of the stamps on this and the facing page celebrate the launching on January 2, 1959, of "Mechta," the Soviet space probe that passed within 5,000 miles of the moon and then entered an orbit around the sun as a tiny man-made asteroid. By contrast, the Danish stamp below portrays an ancient shield, elaborately decorated with solar symbols; it was preserved for many centuries in a chieftain's tomb.

At the left are two stamps: the upper one from West Germany, and the lower from East Germany, that remind us of the close relation between atomic physics and modern astronomy. Planck's constant, h, is of basic importance in reading the message of starlight. It enters into practically every formula the astrophysicist uses

Nuclear physics and astronomy are related in this 20-pfennig rose-brown design put out by West Germany in 1955. The inscription at the bottom reads, "To promote research."

Left: Max Planck's contributions to quantum theory are remembered on two East German stamps issued in 1958 for the centenary of his birth. One of these is this 10-pfennig gray-green issue that bears Planck's famous quantum constant "h," which has many essential applications in modern astrophysics.

Emanuel Swedenborg, pictured on this 10-ore violet issue of Sweden in 1938, was among the first to theorize that the Milky Way is part of a larger cosmic system. The stamp marked the 250th anniversary of his birth.

Right: The archeological motif of this 60-ore dark blue Danish stamp represents the sun god's chariot bearing a solar emblem, and reminds us of astronomy's mythological antecedents.

Left: To mark the centenary of its naval school, Portugal issued this brown-red, 1-escudo stamp, one of four in a series. Center: In the Netherlands Antilles, on the island of Curacao, are located a geophysical-astronomical observatory and one of the Baker-Nunn-camera satellite-tracking stations of the Smithsonian Astrophysical Observatory. This 15-cent adhesive is light blue. Right: In 1957, Switzerland printed a 5 + 5-centime brown-carmine semipostal for the 250th birthday of its brilliant astronomer-mathematician, Leonhard Euler (see January issue, page 141, for another Euler stamp).

The midnight sun shines over a wartime convoy making its way through Arctic seas. This is a 7-ore, slate-colored Norwegian pictorial, one of a long series of stamps issued in 1943-45, during the later years of World War II.

to deduce the physical properties of the sun, stars, and nebulae, from observations of their spectra.

Perhaps most pleasing to the eye of any astronomical instrument is the armillary sphere, with its symmetrical form. It appears on the Portuguese, Swiss, and Argentine stamps on this page. During the Middle Ages armillaries were in widespread use for measuring co-ordinates of sky objects. The rings on these instruments are marked in degrees to match the ecliptic, meridian, and other important circles of the celestial sphere. Tycho Brahe, at the end of the 16th century, observed with armillary spheres up to 9¼ feet in diameter.

In northern Norway the sun does not set in midsummer, but passes low over the northern horizon at midnight. Evidently, in the pictorial at the left, issued by the wartime Norwegian government-in-exile, the convoy is headed westward, returning from Russia to the Atlantic Ocean.

In years to come, the science of astronomy will continue its rapid growth into unknown regions with tools undreamed of today. As our science touches everyday life more closely, the number of stamps with astronomical themes should increase accordingly.

An armillary with zodiacal signs on the ecliptic band distinguishes this violet-brown 1946 Argentinian stamp of 60 centavos denomination.

Romania pictures the Soviet "Mechta" rocket with the 3.25-lei blue-on-pink airmail at the left. The inscription describes the probe as the first artificial planet in the solar system. At the right, the sun and observatory domes are depicted on a 1-forint red and ocher stamp of Hungary, recently issued to publicize International Geophysical Year research.

OBSERVING THE SATELLITES

Van Allen Radiation Belt

THE most significant discovery made so far with artificial satellites is the region of intense cosmic radiation girdling the earth within 20,000 miles of its center. First reported in May, 1958, by James A. Van Allen, State University of Iowa, it was promptly confirmed in Soviet announcements. Great scientific interest in the phenomenon caused instruments for its study to be included in more than half of the 11 earth satellites successfully launched, and in all four of the space probes that attained great distances from the earth.

The initial announcement was based on a study of data gathered by Explorers I and III, launched last year on January 31st and March 26th, respectively. Their Geiger counters met with cosmic ray intensities over 1,000 times greater than expected, and the counter circuits jammed repeatedly whenever the satellites entered the belt.

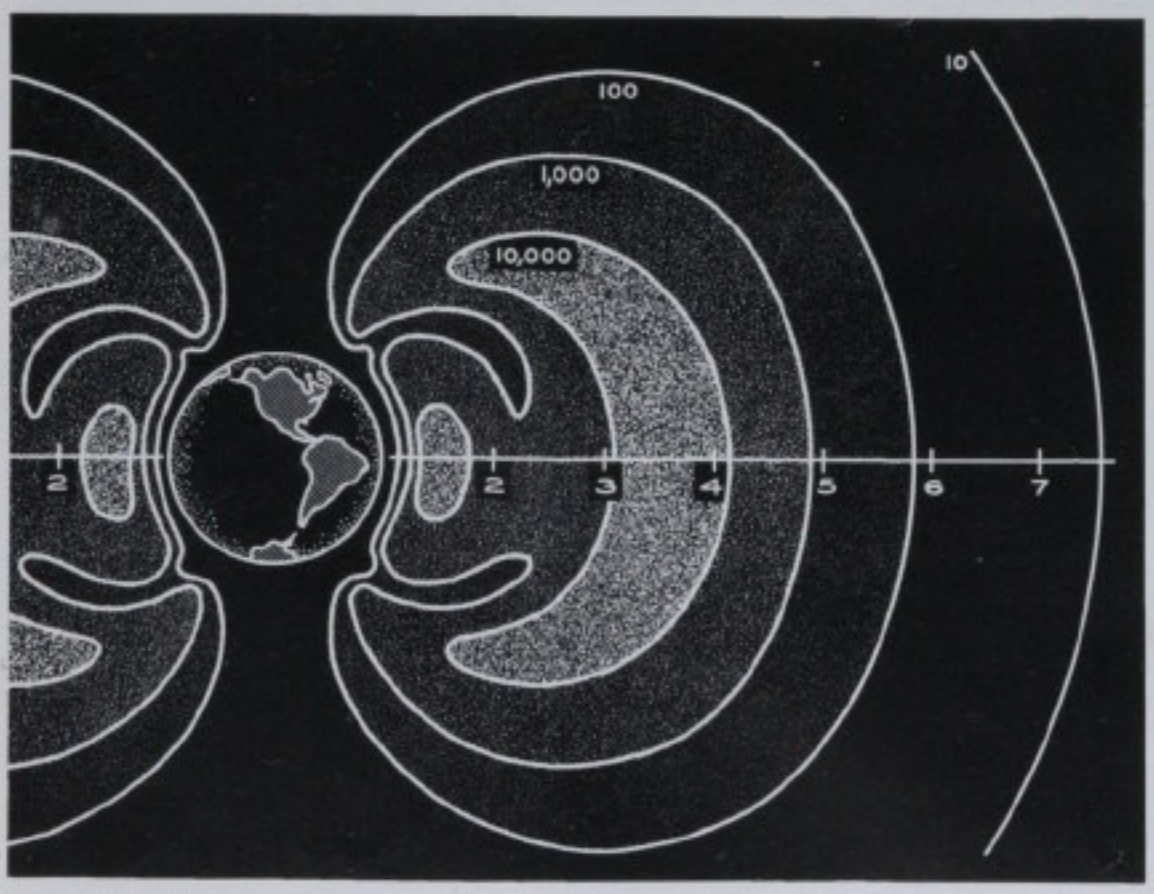
Explorer IV went into orbit July 26th, carrying special instruments that provided a much more detailed map of the radiation zone. In addition, it monitored the closely similar radiation resulting from the three high-altitude nuclear explosions of Project Argus. Details have only recently been made public of these blasts on August 27th, 30th, and September 6th, about 300 miles above latitude 45° south, longitude 10° west, over the South Atlantic Ocean.

The Argus experiment, proposed by N. C. Christofilos, of the University of California's Radiation Laboratory, has greatly aided in understanding cosmic rays. The long persistence of the extra radiation caused by the explosions, and its confinement within a thin layer bounded by surfaces of constant magnetic potential, proved the earlier conjecture that the earth's magnetic field traps charged particles from space to form the concentrations we know as the Van Allen belt. Also, the third blast produced a brilliant red aurora near the Azores, a location consistent with the entrapping theory.

Before World War I, the Norwegian physicist Carl Störmer had predicted that fast-moving charged particles from space could be captured by the earth's magnetic field. His calculations showed that under certain conditions an incoming particle would be forced to spiral around a magnetic line of force, back and forth from one hemisphere to the other. (See the diagram in the May, 1958, issue, page 342.) Only the points of reflection lie deep enough within the earth's atmosphere for the particles to lose appreciable energy by collision with atoms of air, thereby producing auroras.

Detailed cross sections of the radiation zone were measured by means of the space probe Pioneer III in December, 1958, both on its outward flight to about 65,000 miles and on its return. Its counters indicated that there was still some remaining effect from the third Argus explosion. The measurements showed that there are actually two natural radiation regions. Peak intensity for the inner zone amounted to 40,000 particles per square centimeter per second, at a height of about 6,000 miles from the earth's center. Higher than this, counts diminished to about 1,000 per second at 10,000 miles, and then increased to a second maximum, comparable to the first, at about 14,000 miles.

Beyond 30,000 miles, the counts had dropped to less than 10 per second, and continued to decrease toward a limiting value of $2\frac{1}{4}$ a second. This limit indicates that in interplanetary space, at the earth's distance from the sun, the flux of charged particles is approximately 3.6 through each square centimeter each second.



The Van Allen radiation belts, with distances given in earth radii. Radiation intensity, represented by the contours, is in counts per second. Because of the sun's influence, these zones may be expected to fluctuate over the 11-year solar cycle. Data from 1958ε suggest that there is a close relation between high-latitude auroras and the outer high-intensity region. Adapted from "IGY Bulletin" of the National Academy of Sciences.

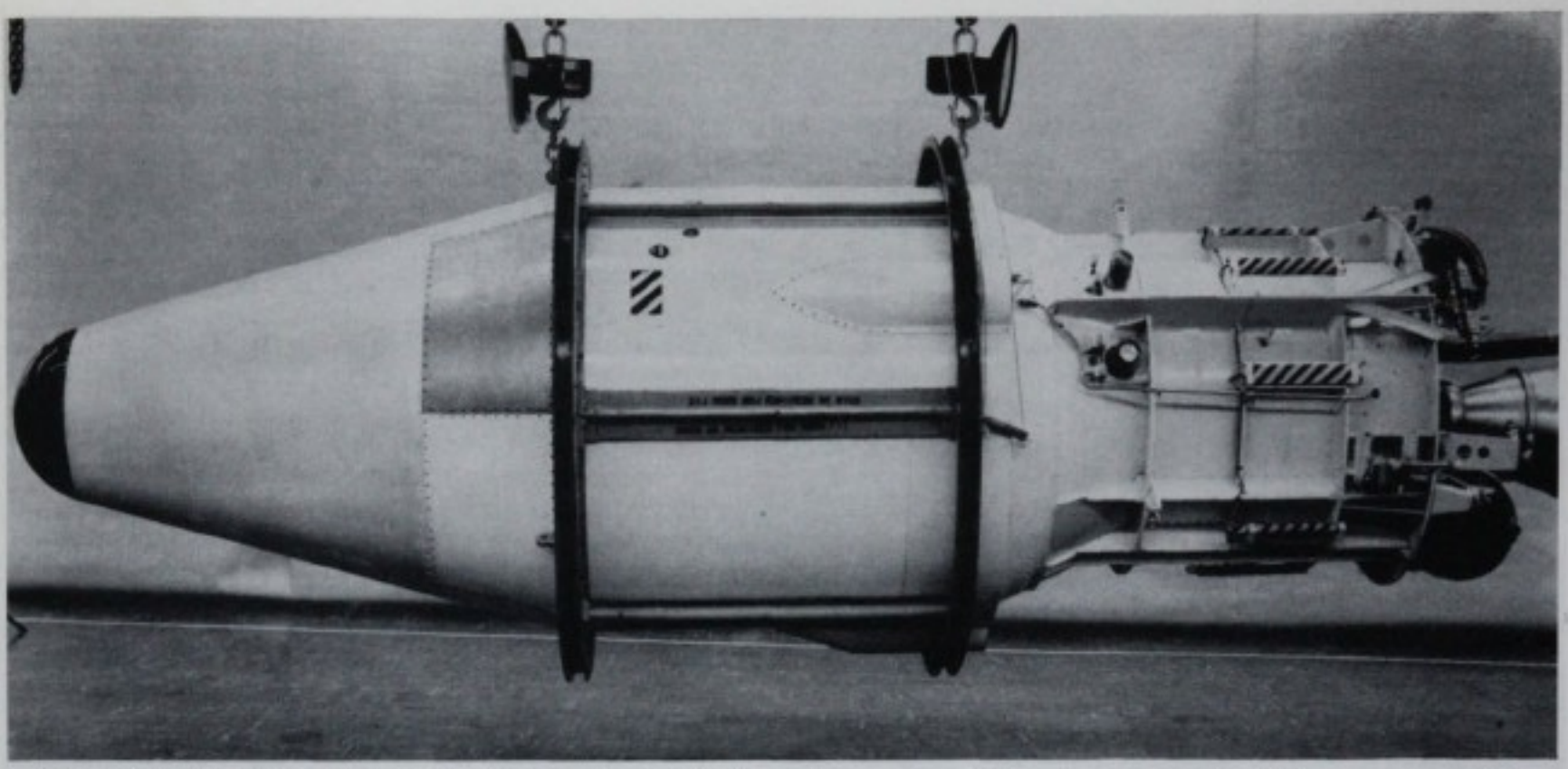
Discoverer II

ONE of the most elaborate satellite experiments yet undertaken by the United States was Discoverer II, under sponsorship of the Advanced Research Projects Agency. It was the first artificial satellite to carry a recoverable instrument package, though the attempt to return a payload from orbit was only partially successful. Controlled stabilization of this satellite, 1959γ, besides being necessary for the recovery attempt, was an essential step toward eventual manned space travel.

Discoverer II was launched from Vandenberg Air Force Base in California on April 13th at 21:18 Universal time. After burnout of the first-stage booster, which was a Thor intermediate-range ballistic missile, the separated second stage coasted upward, while it was guided into firing orientation by controlled jets of nitrogen gas. Then the radar station at Pt. Mugu, California, radioed the command signal for second-stage ignition. Meanwhile, two down-range U. S. Navy vessels were tracking the missile and receiving its telemetry.

The entire second stage, 19.2 feet long, five feet in diameter, and weighing 1,600 pounds, was launched into a low-altitude, short-life polar orbit. This structure, built by Lockheed Aircraft Corp., was powered by a gimbal-mounted Bell engine, whose fuel was unsymmetrical dimethylhydrazine and red fuming nitric acid.

After the second stage burned out, its gas jets turned the missile until it was traveling tail foremost, and thereafter they operated continually to keep the long axis horizontal and in the direction of travel as the satellite circled the earth. This was accomplished with the aid of an infrared detector that scanned the horizon and controlled the jets. Such stabilization requires relatively little thrust if the orbit is nearly circular. An inertial package containing gyroscopes and accelerometers guided the stabilization around the other rotational axes. Thus the second stage was an oriented space platform, a very desirable arrangement for cosmic ray measurements.



The entire 19-foot second stage of a Discoverer satellite is seen here suspended in a ring-type cradle. The motors are at the right, fuel tanks in the center, and nose cone at the left. A cone of somewhat different design, carrying the re-entry capsule, was fitted on Discoverer II. Official U. S. Air Force photograph.

In all, 105 telemetry channels were used to transmit information to earth from Discoverer II. Of these, 34 reported on the performance of the stabilization system, while others carried instrument readings of upper-atmosphere conditions of importance for future animal-carrying Discoverers. The radio signals from the satellite were received "loud and clear," unlike those from Discoverer I (page 320, April issue). Together with part of the regular Space Track network, special antennas were used in California at Vandenberg and Pt. Mugu, in Alaska at Kodiak and Annette Island, and in Hawaii at Kaena Point.

Calculations based on the radio observations of 1959γ showed that initially its orbital period was 90.62 minutes (counted from perigee to perigee), and that its height was varying between 232 and 156 miles. As an orbital inclination of 90 degrees was intended, the firing from Vandenberg was aimed about three degrees west of due south, to compensate for the earth's rotation.

Launching Discoverer II at midday resulted in its being unobservable optically over much of the earth's surface. Most of each southward passage occurred in daylight, each northward one at night. Only in polar regions could this low-flying satellite be seen under twilight conditions.

In latitude 89° 59′ 37″ south, at the American IGY base close to the South Pole, the satellite was observed every 90 minutes, weather permitting. Timed visual observations were radioed to Space Track at Bedford, Massachusetts.

Discoverer II was photographed at College in Alaska, on April 26, 1959, at 10:50 UT, during its 202nd revolution. Estimates of the maximum brightness of 1959γ are about magnitude +2. The satellite is believed to have fallen to earth sometime between its 203rd and 206th revolutions, according to Dr. E. W. Wahl of Space Track.

The re-entry capsule, carried in the nose of the second stage, was 27 inches long and 33 inches in diameter, weighing about 160 pounds. Originally it was planned to eject the capsule on command, and to snatch its parachute in mid-air by airplanes flying in pattern near the Hawaiian Islands, but the separation-timing equipment aboard the satellite did not permit recovery in that area. However, after 27 hours in orbit, the timing device did trigger separation of the capsule, with the aid of explosively actuated pins and preloaded springs. Immediately afterward the capsule's retrorocket fired automatically, to slow the vehicle to re-entry velocity. It had a special nose cone, designed to melt and vaporize gradually, thus dissipating the heat of atmospheric friction. Following the jettisoning of the nose cone, a parachute was opened to slow the fall.

Radio contact was made with the capsule, and three fishermen north of Spitzbergen report having seen the descending parachute. However, early searches over the sea failed to pick up the re-entry vehicle.

The lost capsule contained film packs used for recording cosmic rays. Two groups of films, arranged horizontally and vertically, were intended to measure the intensity and direction of cosmic radiation, and to distinguish among electrons, protons, and heavier charged particles. Neutron density, not detected by the film packs, was to have been measured by the changes induced in a metallic bismuth detector.

MARSHALL MELIN
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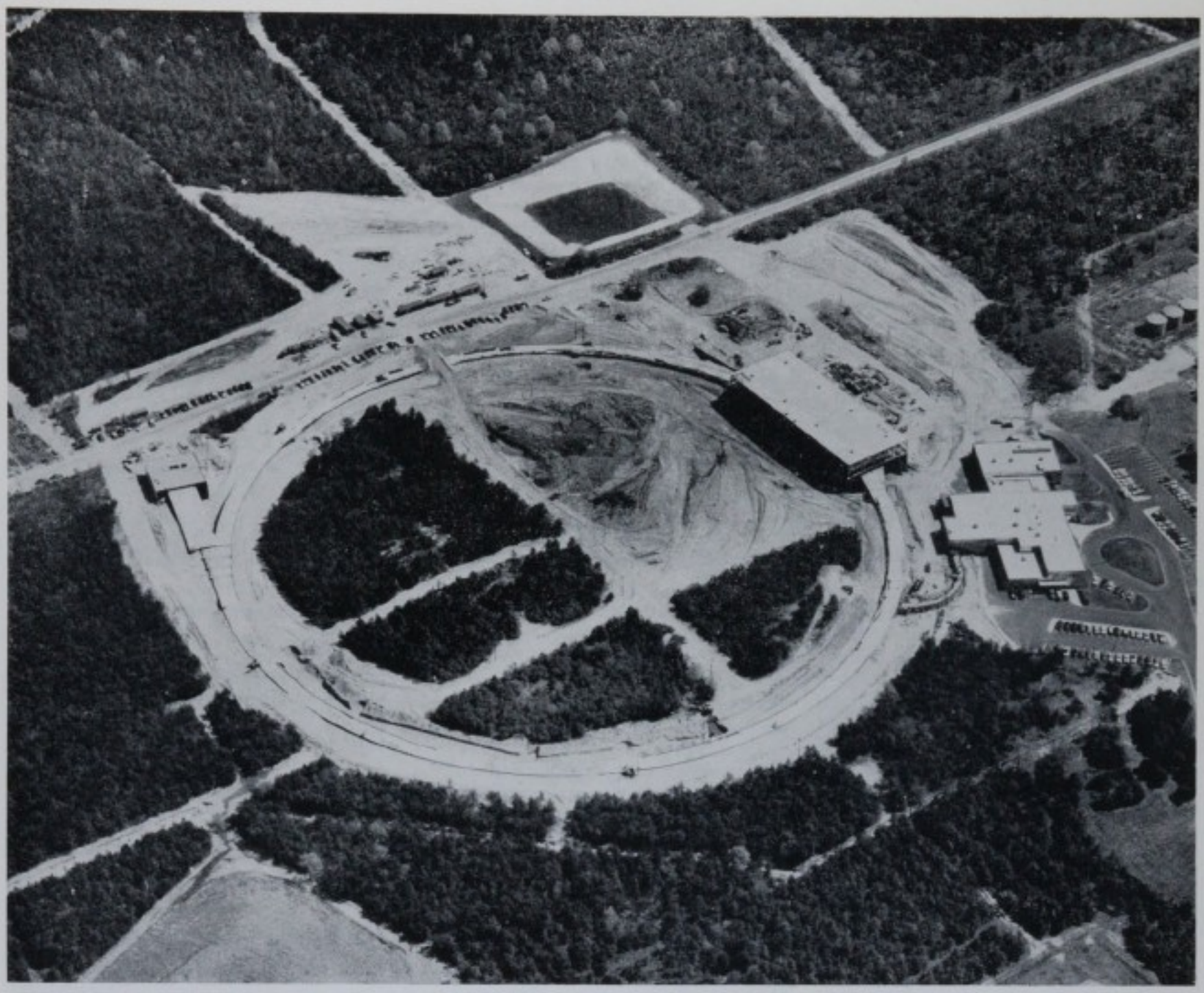
AMATEUR OBSERVATIONS OF A FLARE STAR

One of the brightest variable stars of the flare type is AD Leonis, easily recognized in small telescopes because it is a 9th-magnitude object just five minutes of arc west of Gamma Leonis. Like other flare stars, it is a red dwarf whose spectrum shows bright lines of ionized calcium. Normally it remains at its minimum brightness, visual magnitude 9.4, but at times unpredictably brightens to about 9.0 and fades again, most of the change occurring within a few minutes.

At Hinsdale, Illinois, on the evening of April 12, 1959, Donald Engelkemeir succeeded in observing a flare of AD Leonis photoelectrically. He used a 1P21 photomultiplier with yellow and blue filters, mounted at the Newtonian focus of his 8-inch reflector.

Measurements in yellow light show that at 9:35 p.m. Central standard time the star was close to its normal faintness. Then it increased more and more rapidly until the brightest magnitude, 8.67, was recorded at 10:26. Afterward, AD Leonis faded, to magnitude 9.27 by 10:52, and then more slowly. The blue-light observations, which were fewer in number, showed a larger range, indicating the increased blueness of the variable during its flaring.

Mr. Engelkemeir is a member of the American Association of Variable Star Observers, to which he reported his observations in detail. They have been published in Harvard Observatory *Announcement Card* 1433.



The new 25-billion-electron-volt alternating gradient synchrotron at Brookhaven National Laboratory, Long Island, New York, in an aerial view looking northeast. This will be the largest and most powerful particle accelerator ever built. The ring, which has since been covered with earth for shielding purposes, is about a sixth of a mile in diameter. At the left, and tangent to the ring, is the building containing a 750,000-volt Cockcroft-Walton generator and a 50-million-electron-volt linear accelerator, which give the protons their initial boost. Located on the ring at the right is the target building, where reactions produced by the machine's intense proton beam will be studied. The service building, far right, contains laboratories, the power plant, controls, machine shop, and offices. Engravings courtesy "IRE Student Quarterly."

New Brookhaven Accelerator

FROM A KNOWLEDGE of the minute world of atoms comes the basic information needed to understand the processes that make the stars shine and form elements in their interiors. The Brookhaven National Laboratory proton accelerator that will go into operation next year will mark a new high in energy that can be given to elementary particles used to unlock the secrets of the atomic nucleus. It is located in Upton, New York, 70 miles from New York City.

Known as an alternating gradient synchrotron, the new device bears little resemblance to the earliest cyclotrons that paved the way for its development. The first cyclotron, built in 1931, could conveniently be housed in a small room, and gave particles an energy of only 80,000 electron volts. By contrast, the giant ring pictured above is about 850 feet in diameter — three football fields could nearly be placed across it — and is capable of giving particles 25 billion electron volts of energy.

This installation is composed essentially of three accelerators in tandem. First, protons are obtained by ionizing hydrogen gas and are accelerated by a Cockcroft-Walton generator, which gives them an energy of 750,000 volts. Next they are fed into a linear accelerator, where their energy is increased to 50 million volts. It consists of 124 tubes of different lengths and diameters, placed in line within a tank about a yard in diameter and 110 feet long. In this device the protons are bunched, like beads on a string, as this is essential to the operation of the synchrotron. In every minute there are 20 bursts of 12 bunches each. The beam is about 1.7 inches in diameter when it is injected into the big ring.

The alternating gradient synchrotron itself contains a gigantic doughnut tube having an elliptical cross section 6½ by three inches, with a radius of 421½ feet. Spaced along this tube are 12 radio-

frequency accelerating stations. At each of these the bunches of protons are given an energy increment of 8,000 volts, or 96,000 volts per revolution. To reach the 25-billion-volt level, the protons must go around the ring 260,000 times, or 130,000 miles.

The speed of the protons increases as their energy grows, rapidly at first, then more slowly as they approach the velocity of light. Therefore, they make each revolution in less time than the previous one, and special ferrite rings are used to cause the accelerating cavities to resonate at the proper frequency. The cavities are operated at the 12th harmonic of the revolution frequency, with 12 equally spaced bunches of protons traveling around the ring during each burst.

As the speed increases from less than a third to within a very small fraction of the velocity of light, the frequency of the cavities is increased from 1.40 to 4.46 megacycles per second, in order to be in phase with the bunches and to accelerate them at each passage.

Once the protons have acquired the full amount of energy, the target is introduced into the beam, and the reactions that take place as they bombard the target material are studied with a variety of instruments. It is planned eventually to deflect the beam out of the vacuum chamber so that many simultaneous experiments can be set up along its path.

To keep the proton beam in orbit and to focus it, 240 magnets are used, each deflecting the beam 1½ degrees. Power is to be supplied by a 12-phase 36,000-kilovolt-ampere generator, with a 47-ton flywheel and a 5,500-horsepower motor. At peak current, about 14 million joules of energy will be stored in the magnetic field, and over 10 million watts will be dissipated as heat in the windings, which are water-cooled. The magnets are gigantic — one type used has a core weighing 15 tons and 3,200 pounds of copper in the windings. A total of 4,000 tons of magnet steel will be needed to build them.

Different types of magnets are grouped to provide a strong net focusing action on the proton beam. The bunching action is necessary to assure proper acceleration at the 12 radio-frequency stations; moreover, it tends to equalize the energy of the individual protons making up the bunch.

The housing for the accelerator must protect not only the instrument but the operating personnel. The tunnel opening is about 18 feet square, and the structure has a circumference of about half a mile. This tunnel is now covered with earth for additional radiation shielding. The target building is 100 feet wide by 252 feet long, and is 40 feet high. A 40-ton traveling crane spans its width, and 14,000 tons of concrete shielding covers the portion of the ring that passes through the building.

The accelerator ring is supported on 120 sets of four piles each, sunk about 50 feet into the sand and gravel underlying Long Island. This elaborate mounting is necessary to maintain the delicate alignment of the great instrument.

The synchrotron is being built and will be operated by Associated Universities, Inc., with funds provided by the Atomic Energy Commission. The Brookhaven instrument is slightly larger than the similar device under construction at Geneva, Switzerland, by the 12-nation European Organization for Nuclear Research. Plans for erecting a 50-billion-electron-volt synchrotron in the U. S. S. R. have been announced recently. (For a fuller discussion of the Brookhaven accelerator, see the article by R. A. Beth and C. Lasky in the December 5, 1958, issue of *Science*, page 1393.)

Completion of the monster Brookhaven synchrotron in 1960 will provide a research tool of the same importance for exploring the subatomic world as the Palomar 200-inch telescope is for the exploration of the cosmos. The two kinds of investigation are, in fact, closely related.

The junction of the ring-shaped housing of the synchrotron and the building for the initial accelerators. At the left, tangent to the ring tunnel, is the room for the Cockcroft-Walton generator, while the 110-foot-long, 50-million-electron-volt linear accelerator is supported on the pedestals in the center of the picture. The "I" beam at right center carries the magnet sections for the main synchrotron ring.

LOCATION OF THE NORTH MAGNETIC DIP POLE

During the last decade a number of determinations have been made of the position of the north magnetic dip pole — the point on the earth's surface at which the south end of a freely suspended magnetic needle would point directly downward.

From their analysis of this material, K. Whitham, E. I. Loomer, and E. Dawson, of the Dominion Observatory, Ottawa, have concluded that the position of this pole at the beginning of 1960 will be latitude 74°.8 north, longitude 99°.6 west. This corresponds to a point north of the Canadian mainland, between Prince of Wales Island and Bathurst Island. The dip pole is drifting in a northerly direction, at a rate of about 55 miles per decade.

The dip pole should be distinguished from the geomagnetic pole, which is the intersection of the axis of the earth's dipole field with the surface of the earth. The north geomagnetic pole is shifting very slowly; at the beginning of 1955 it was at latitude 78°.3, longitude 69° west, some 600 miles northeast of the dip pole.

The findings of the three Canadian scientists were reported in the March, 1959, issue of the journal *Arctic*.

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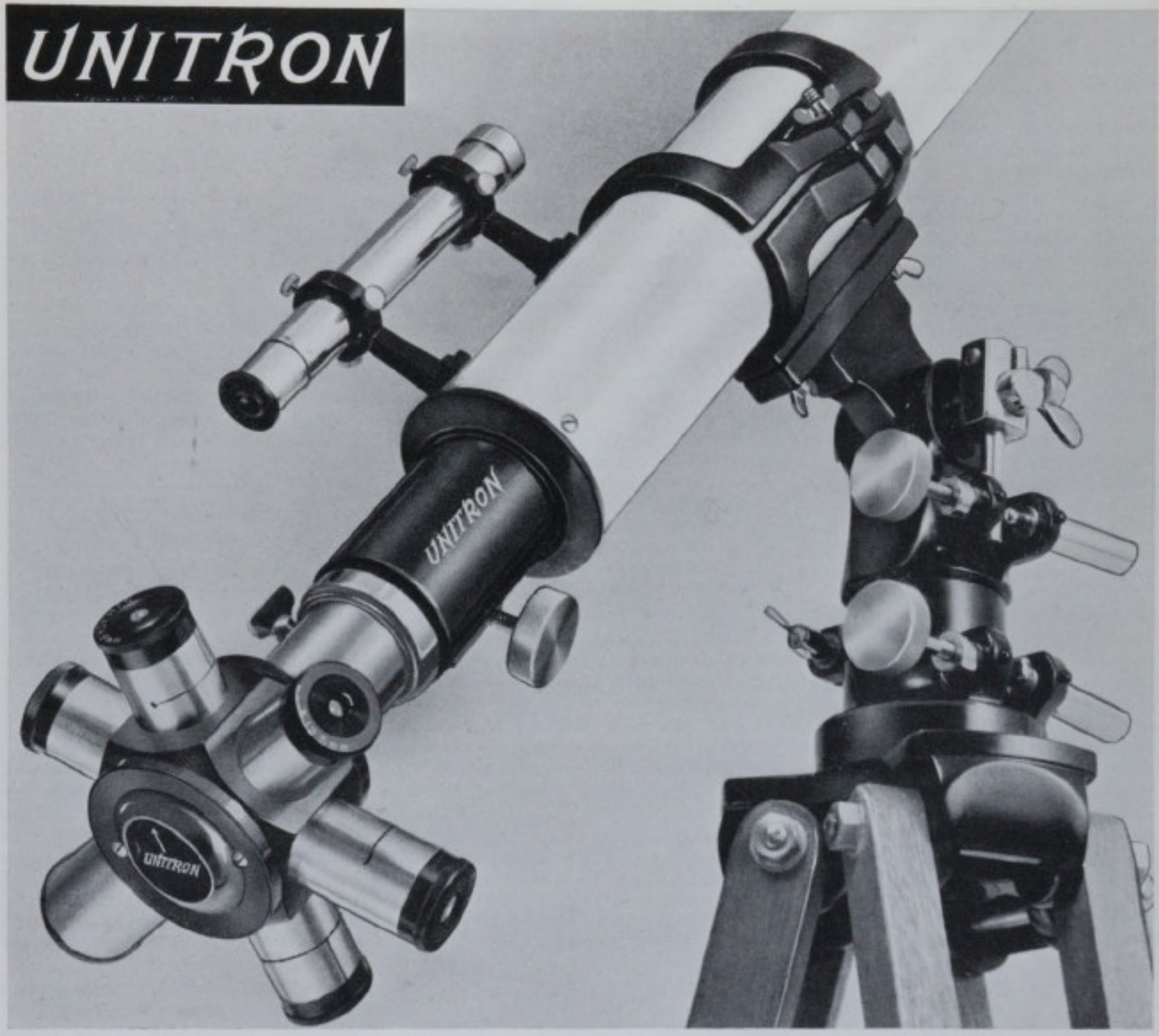

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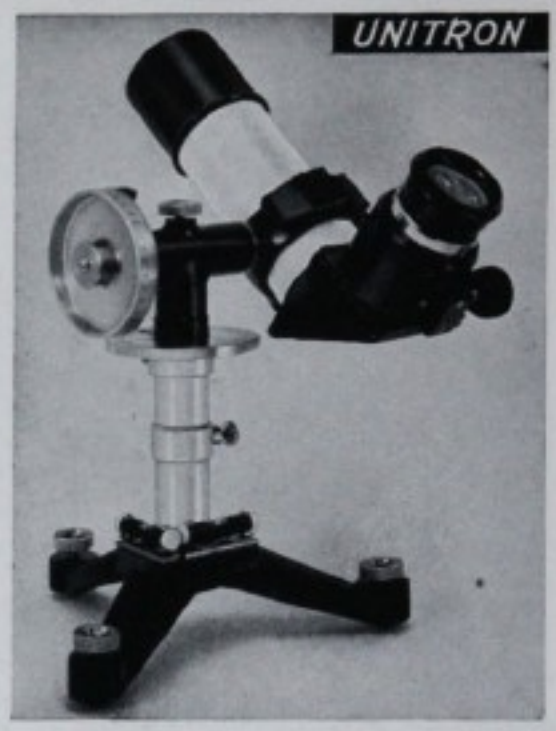

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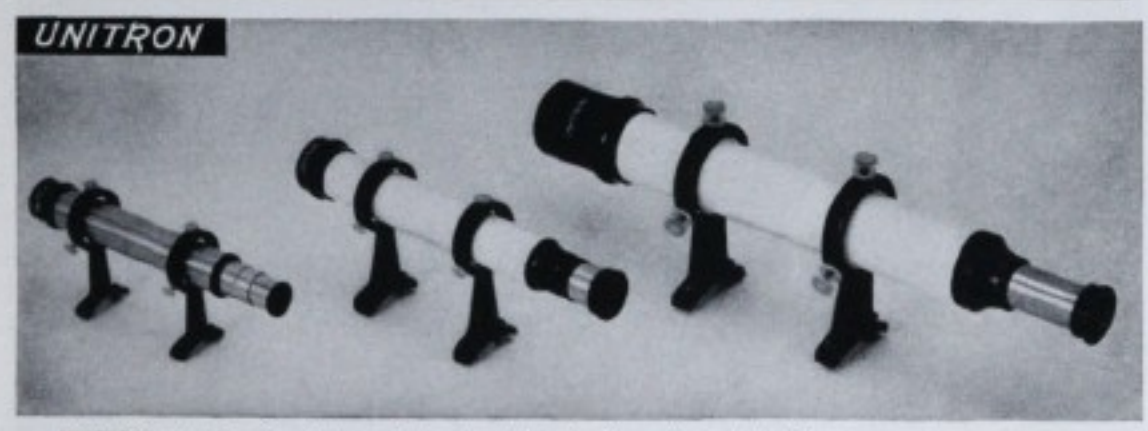

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OBSERVER'S PAGE

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Drawing the Moon's Surface

IN RECORDING lunar surface details pictorially, selenographers resort to several artistic media. Photography, pen and ink, and pencil are the most frequently used. The first of these often leaves much to be desired, despite its fidelity of rendition, for photographs may not show fine details that can be seen visually in the same telescope. Pen-and-ink work is mainly used by cartographers when mapping a lunar region without regard to the direction of illumination.

To record the delicate details that are visible in moments of good seeing, the best means is a pencil sketch made at the telescope. Russell W. Porter, in the October, 1930, *Scientific American*, described a method of pencil drawing that is simplicity itself.

The materials needed are drawing paper, preferably the type used for pencil or charcoal rendering; pencils of grades 2H, 4B, and 6B; and two ruby erasers, of which one is sharpened to a fine point. An artist's stump, which is a solid roll of soft blotting paper, pointed at each end, is handy for blending or shading delicate changes in tone.

The drawing paper is prepared by sprinkling the surface with a small amount of graphite scraped from the 6B pencil. This is gently rubbed into the paper with a soft rag or tuft of cotton to give an over-all medium gray tone. The graphite should not be scrubbed in nor should any excess be left on the surface. Experiment to find the correct amount.

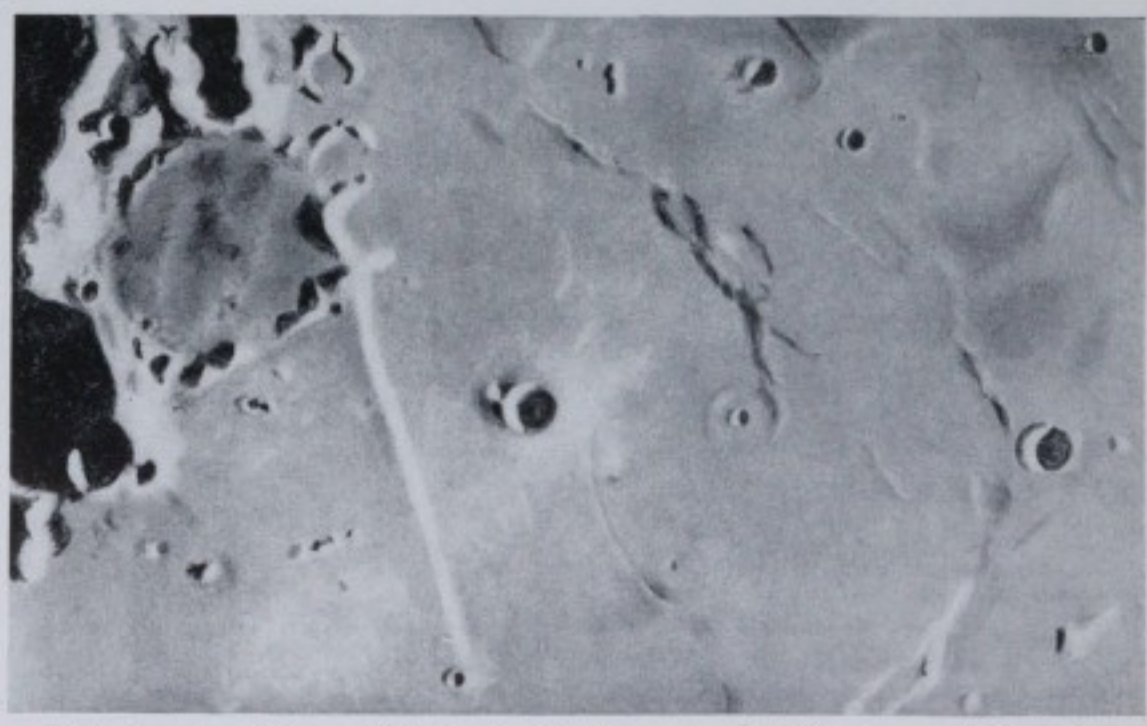
Thus treated, the surface of the paper represents the apparent monotone of the lunar surface without detail. During observing, the darker areas are to be filled in with the 4B pencil, while the lighter regions and highlights are picked out with the eraser.

At the telescope, the power used will vary. Start with 15 per inch of aperture and increase this as seeing permits. Excellent work can be done at 20 per inch of aperture. The drawing paper should be illuminated by a white light that approximates the intensity of the moon's surface as seen in the eyepiece.

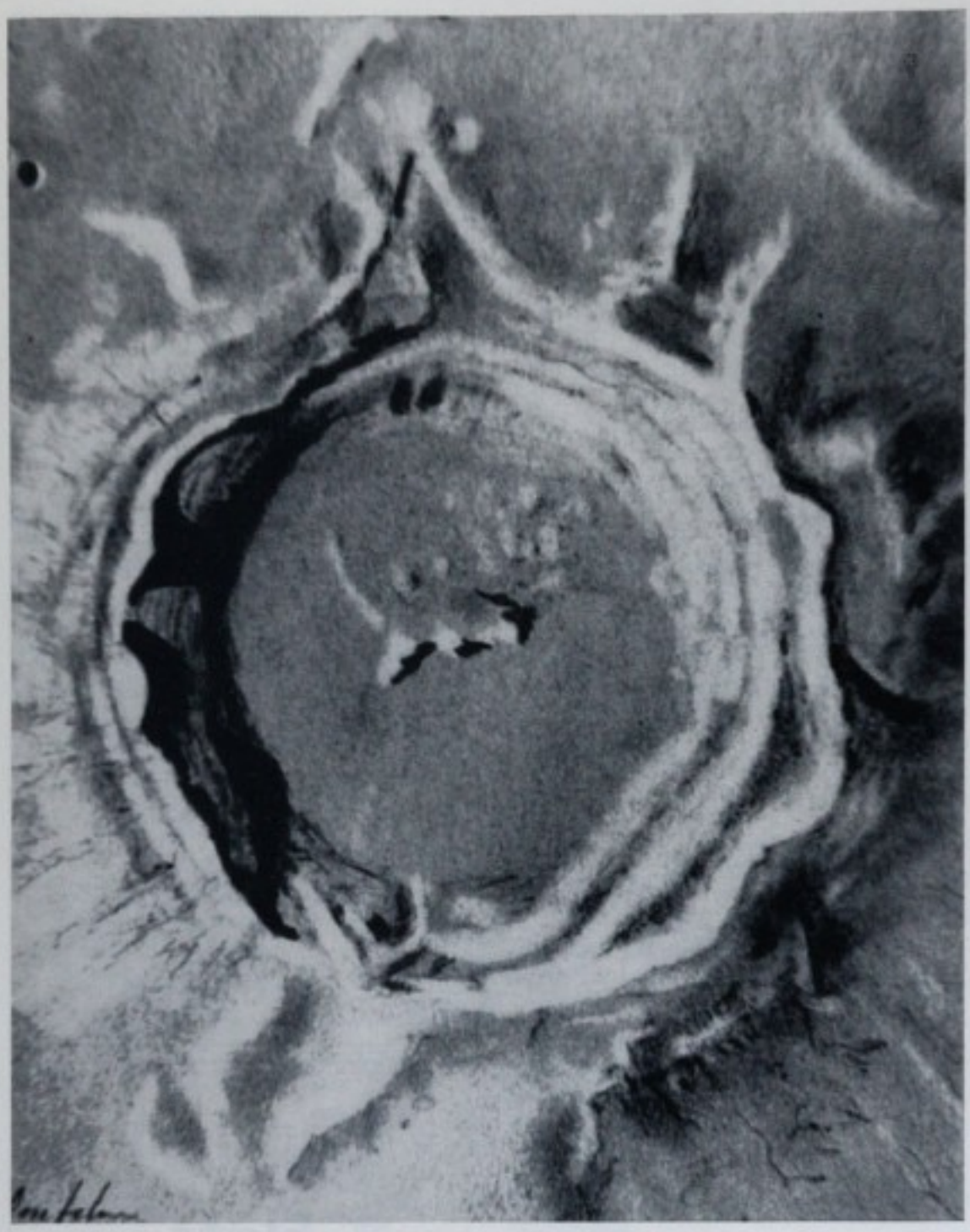
In drawing craters, the heavy shadow areas are filled in first. Next is added the detail on the crater walls. Then the crater floor is searched for rills, clefts, and craterlets, and these are depicted. The main highlights are now "erased," while with the 2H pencil and stump the edges of the highlights are smoothed and corrected.

A small crater is quickly depicted by erasing the entire area of the crater and then filling in the shadow. This is easier than trying to use rubbing out to form a thin line of light that occurs when the sun is low or the craterlet is deep. A cleft is easily "drawn" by using a sharp-pointed eraser; the shadow line, which gives depth to the feature, is penciled in on the proper side. Small mounds and hillocks show both as lighter and darker areas, depending on the amount of slope and the angle of the sun. Gently brush the surface of the paper to lighten an area slightly. Use a finger or the stump for darkening small areas.

Restrict the drawing to one crater or formation, and avoid scaling the work too



This drawing of the neighborhood of the lunar Straight Wall was made by Ray G. Coutchie, using the method described in the text, on February 1, 1959, at 11:30 Universal time. The moon was one day past last quarter, the sun's colongitude being 188°.1. The Straight Wall is the streak at left center, appearing bright because its face was catching the light of the setting sun. Mr. Coutchie used a 10-inch f/9.6 reflector at 400x.



Mr. Coutchie made this pencil sketch of the great lunar crater Copernicus on February 18, 1959, when the moon was 10.3 days old. The time was 3:30 UT, and a power of 345 was used on his 10-inch reflector. The sun's colongitude was 31°.0, and the rather low lighting shows the strongly terraced form of the crater's inner walls. On the upper part of the crater's floor is a group of low hillocks. This reproduction is enlarged slightly from the original drawing.

large or too small. The accompanying drawing of Copernicus was originally drawn 4½ by 5½ inches in size. Work as rapidly as skill and seeing permit. It is seldom advisable to spend more than 30 minutes on one drawing – as the shadows move rapidly across the surface the appearance of details changes quickly. Use moments of poorer seeing to fill in the shadow areas. If seeing is better than normal, block in the outlines of the jet-black shadows and fill them in later, though no other part of the drawing should be altered after you have left the telescope.

Perspective is important, as in most cases the region under observation is seen obliquely. Checking a good photograph beforehand is a help, as from it the general outline of the main features can be lightly sketched in with the 2H pencil. The libration of the moon on the night the drawing is made must correspond to that of the photograph, for libration and solar altitude affect the appearance of lunar features greatly.

Do not be discouraged if your attempts are not photographic in appearance. In order to get the feeling of light and shade, try copying a photograph (but do not use a photograph at the telescope while actually sketching). Good basic proportion and positioning of detail are very important. Use features already drawn to judge the size and location of additional details. Once you have mastered the technique, you will be able to make a rendition that has a definite value.

For a lunar drawing to be scientifically useful, it should be labeled with the date, time, and quality of the seeing; also the telescope aperture and magnification. Experienced lunar observers habitually specify the solar illumination by the sun's colongitude at the time of observation. This can be obtained, together with the libra-

A word from Ward . . .

"CAVEAT EMPTOR!"

A friend of mine — a much brighter scholar than I am — told me that the Latin phrase, "Caveat Emptor!" had its inception at a Thieves' Market which flourished in ancient Rome many years ago. "Caveat Emptor!" means simply, "May the buyer beware!"

What a wealth of shady practices that slogan brings to mind! I can almost see a fly-by-night operator, with a name like Polonius Maximus, conning a customer in fast-talking Latin. "Oh, worthy friend," says Polonius, "look at this genuine, super de luxe, guaranteed Arabian camel! Look at its teeth! By the brow of Jupiter, I swear this noble beast was last owned by a kindly old lady in Passadenium — and isn't even broken in yet!" Naturally, the noble beast drops dead at the city gates.

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tions, from the *Handbook* of the British Astronomical Association or from the *American Ephemeris*.

The altitude A of the sun, seen from a point on the moon's surface whose selenographic longitude and latitude are l and b, respectively, is given by the formula:

$$\sin A = \sin b \sin b_o + \cos b \cos b_o \sin (C + l),$$

where C and b_o are the colongitude and the selenographic latitude of the sun.

RAY G. COUTCHIE
22018 Ybarra Rd.
Woodland Hills, Calif.

ASTROPHOTOGRAPHY GUIDE

The Eastman Kodak Co. has just published a free 16-page booklet entitled *Astrophotography with Your Camera*. Its topics range from simple star-trail photography to exposures on clusters and nebulae with guided telescopes. Tables of recommended films and exposure times are given for various classes of objects. Copies may be secured by writing the Sales Service Division, Eastman Kodak Co., Rochester 4, N. Y.

SUNSPOT NUMBERS

The following American sunspot numbers for March have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

March 1, 143; **2**, 106; **3**, 143; **4**, 150; **5**, 104; **6**, 120; **7**, 127; **8**, 142; **9**, 150; **10**, 134; **11**, 114; **12**, 140; **13**, 158; **14**, 150; **15**, 176; **16**, 175; **17**, 177; **18**, 194; **19**, 171; **20**, 195; **21**, 182; **22**, 170; **23**, 144; **24**, 140; **25**, 158; **26**, 164; **27**, 169; **28**, 175; **29**, 233; **30**, 207; **31**, 195. Mean for March, 158.3.

Below are mean relative sunspot numbers for April by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

April 1, 249; **2**, 242; **3**, 174; **4**, 159; **5**, 124; **6**, 108; **7**, 101; **8**, 132; **9**, 144; **10**, 177; **11**, 197; **12**, 189; **13**, 178; **14**, 193; **15**, 170; **16**, 142; **17**, 109; **18**, 119; **19**, 108; **20**, 132; **21**, 128; **22**, 138; **23**, 186; **24**, 186; **25**, 203; **26**, 184; **27**, 165; **28**, 165; **29**, 160; **30**, 115. Mean for April, 159.2.

Dr. Waldmeier gives the following predictions for the smoothed monthly sunspot numbers for the next five months: June, 154; July, 151; August, 148; September, 144; and October, 140.

Zurich sunspot numbers are broadcast on short-wave frequencies on the 4th and 5th of each month. In North America these can be received on the 5th at 1:35 Universal time on wave lengths of 48.66, 31.46, and 25.28 meters; and at 4:20 UT on 31.46, 25.28, and 19.60 meters. In South America, broadcasts are on the 4th at 23:30 UT and the 5th at 3:45 UT, both being on wave lengths of 31.46, 25.28, and 19.59 meters. This schedule is valid through October, 1959.

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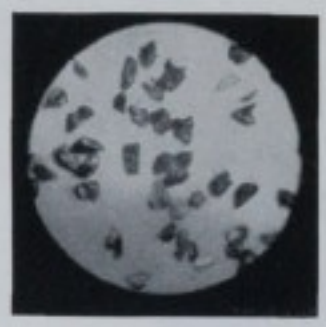

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DEEP-SKY WONDERS

SCORPIUS comes to the meridian about 11 p.m., local time, in mid-June, dominating the entire southern sky. When observing conditions are good, a multitude of clusters awaits the observer. Two of the best globulars in this region are M4 and M80.

Close to Antares, M4 is one of the finest sights in the heavens. Also designated NGC 6121, the cluster is located at right ascension $16^h\ 20^m.6$, declination $-26°\ 24'$ (1950 co-ordinates). It was one of the earliest globulars to be discovered, J. de Chéseaux observing it in 1746, 25 years before Charles Messier noted it. This 6th-magnitude object is 23′ in diameter, and can be easily seen in a finder, but in northerly latitudes it takes a 10- or 12-inch reflector to reveal adequately its globular nature. Its brightness suggests that M4 may be a naked-eye object, and this writer would be interested in hearing from anyone who can so see it.

M80 (NGC 6093) is much less known, and apparently harder to observe. It is located at $16^h\ 14^m.1$, $-22°\ 52'$, about halfway between Antares and Beta Scorpii. Discovered by P. Méchain in 1781, this object is 7th magnitude, fairly bright against its rather dark background, and is 5′ in diameter. M80 is remarkable because Nova T Scorpii 1860 appeared near its center, reaching 7th magnitude. If this nova was a cluster member, it was intrinsically much brighter than ordinary galactic novae. T Scorpii is now fainter than magnitude 12 — perhaps much dimmer.

In the same field of view as M80 are two long-period variables, R and S Scorpii, both near minimum this month. R has a period of 223 days and varies between magnitudes 10.4 and 15.0; S ranges from 10.5 to 14.6 in a period of 177 days.

The region of M80, as depicted by Admiral W. H. Smyth in his "Cycle of Celestial Objects" of 1844. His sketch was made with a 6-inch refractor. Two 9th-magnitude stars are indicated by five-pointed images, while at the right the small triangle consists of R Scorpii (upper left), S (lower left), and the 10th-magnitude star mentioned in the text as possibly variable.

An overexposed image of the 1st-magnitude star Antares (left) and the myriad stars of the globular cluster M4 (right) dominate this portion of a photograph by the 48-inch Schmidt telescope of Mount Wilson and Palomar Observatories. At top center is another globular cluster, NGC 6144, which was discovered by William Herschel in 1784. Its stars are highly concentrated toward its center. The reproduction scale is about 15 minutes of arc per inch. North is at the top.

J. Chacornac discovered the variability of these two stars in 1854, yet both appear in a drawing by Admiral W. H. Smyth as early as 1837.

As may be seen on the facing page, both variables were put in this chart of M80. Incidentally, N. Pogson thought a third star, forming a small triangle with R and S, might also be variable, but no further information is available.

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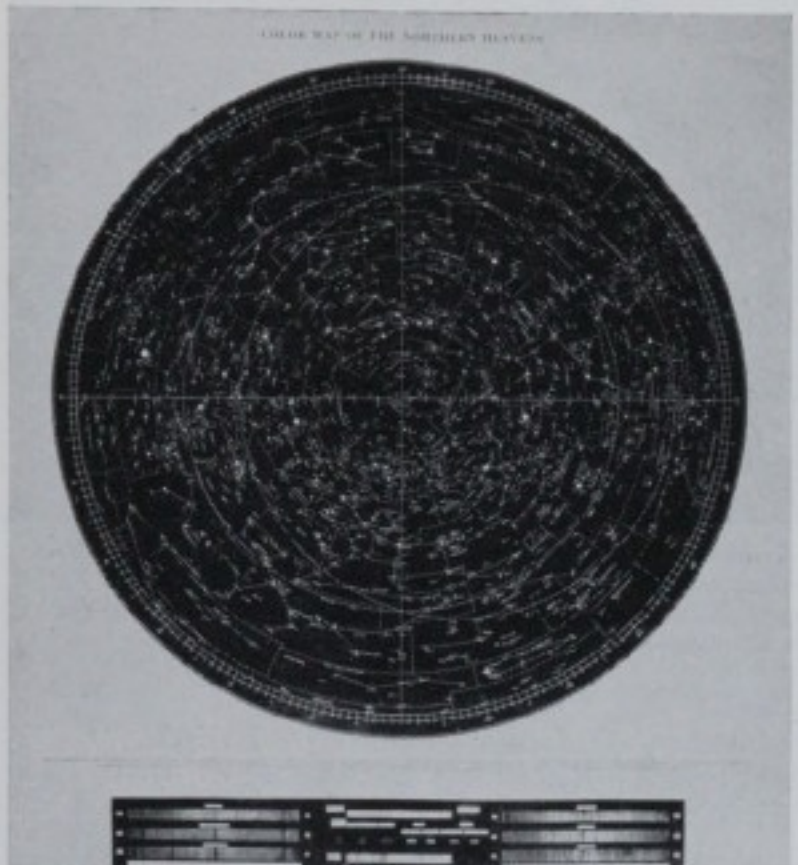

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BOOKS AND THE SKY

THE GREEN FLASH AND OTHER LOW SUN PHENOMENA

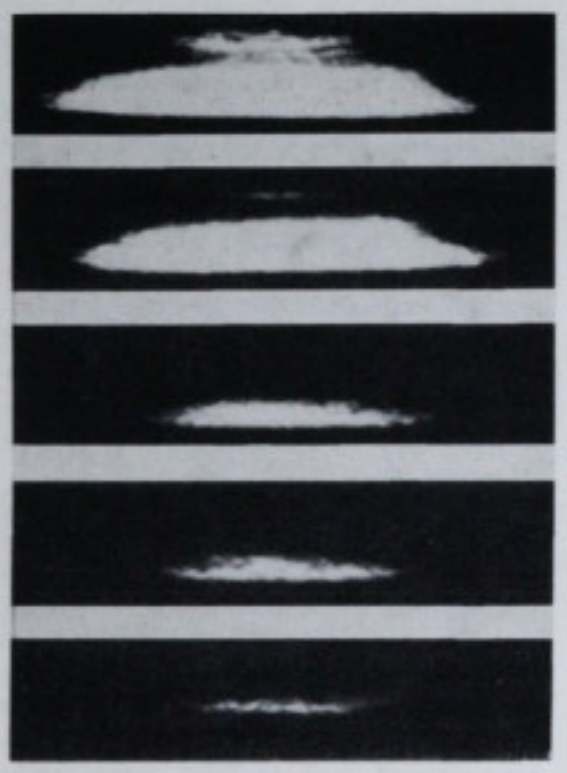
D. J. K. O'Connell, S. J. Interscience Publishers, Inc., New York, 1958. 192 pages. $6.00.

WHEN the upper limb of the reddened sun sets behind a sharply defined horizon, one can sometimes see for a second or so a final flash of green light. It is also occasionally possible to see a fleeting preliminary greenish spark in the instant before sunrise.

Although the green flash may have been observed off and on for thousands of years, the earliest recorded sighting seems to be as recent as 1865, by Swan. The effect was described nicely by Winstanley in 1873: "The green ray . . . begins at the points or cusps of the visible segment of the sun, and when the setting is nearly complete, extends from both cusps to the central space between, where it produces the momentary and intense spark of colored light visible to the unaided eye."

Published for the first time, in Father O'Connell's book, are color photographs of the green flash and green rim, in a beautiful and informative sequence which also includes many pictures in black and white. The author's aim "is to reproduce photographs . . . of the green flash and of kindred phenomena at the rising and setting of the sun (also of the moon and Venus) and of certain experiments carried out at the Vatican Observatory."

The photographs, made under difficult conditions, were taken by C. Treusch, S. J., some with the 60-cm. f/4 reflector and others with the 40-cm. f/15 visual refractor at Castel Gandolfo. Most were made at sunset on the sea horizon of the Mediterranean, although there are also some striking pictures of the sun rising over the eastern hills. The book is surely the authoritative work on the green flash, containing, in addition to the photographs, data on simultaneous visual observations and meteorological conditions, a very complete bibliography, and a good account of the history and qualitative theory of the flash.



On November 27, 1955, C. Treusch, S. J., Vatican Observatory, took these photographs of the sun setting over the Mediterranean Sea. The time difference is 9.6 seconds between the top and bottom pictures. In the last, the sun's rim was a faint blue-green for about one second. From "The Green Flash and Other Low Sun Phenomena," Interscience Publishers, Inc.

This elusive phenomenon was early thought to be physiological in origin, and one notion was that he who could see the flash was bilious by nature. The photographs in Father O'Connell's book will serve to bury such ideas for good, because they assure that the effect is an objective one.

The essential cause of the green flash is now accepted to be refraction and dispersion of sunlight by the atmosphere. The atmosphere acts as a prism, bending the path of light, and the more violet the light the greater the bending. A rising or setting object is normally raised about 35 minutes of arc by refraction, and because of dispersion the green is lifted some 15 seconds of arc more than the red. Thus, when the red sun has fully set, a bit of the top of the green sun is still above the horizon. In tropical or temperate latitudes, the rising or setting sun changes altitude by some 10 or 15 seconds per second of time, and therefore the green flash may be expected to last for about a second, in agreement with the visual observations at Castel Gandolfo and elsewhere.

Granted that refraction and dispersion provide the essential explanation, one may legitimately ask why the flash is usually green, rather than quickly rushing through the spectrum from orange through green to violet. The answer is that most of the orange and yellow rays of the setting sun are absorbed by water vapor and oxygen molecules in the atmosphere, while the violet and blue rays are largely scattered by atmospheric molecules. What gets through to the observer is therefore chiefly red and green, and when the red has set only the green remains.

The Vatican photographs, made with telescopes of adequate focal length, confirm what one expects if these ideas are correct: that the upper limb of the low sun has a green rim for a few moments before setting. This rim cannot be seen with the unaided eye because its angular width is much less than the resolving power of the eye; only when the red sun is fully gone can the eye see the green flash.

The effect is a very capricious one, and Father O'Connell notes that he and Dr.

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The Book was reviewed in the January issue of SKY AND TELESCOPE.

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Robert G. Aitken watched for the flash at Lick Observatory for several months — without success. Many factors influence the detectability, brightness, color, and duration of the flash, among them anomalous refraction, scintillation effects, and the observer's height above sea level. The photographs include a remarkable collection showing how varying atmospheric conditions distort the solar disk at the horizon. Perhaps the most impressive feature of these weird shapes is their symmetry around a vertical axis, indicating that small-scale stratification in the atmosphere occurs in essentially horizontal layers.

One could object that this book is devoted to a quite minor topic. Such a thought is irrelevant, I think, first because Father O'Connell gives an exhaustive account of a rare and brief phenomenon, and second because he adds to an inadequate number of past observations a great treasure of really new information.

Perhaps better balance would be achieved, and the book's utility as a complete and compact summary would be enhanced, if the story of the theory of the green flash were accompanied by a quantitative presentation of such topics as the theory of refraction in gases at different wave lengths, refraction in a spherical atmosphere, and the rate of descent of the setting sun at different latitudes and times of year. For it is always satisfying to know that theory and observation are in accord. But this is scarcely a major criticism; the book has great merit and is a worthy addition to astronomical literature.

STANLEY P. WYATT, JR.
University of Illinois Observatory

TEACHING A UNIT IN ASTRONOMY: GRADES 1-9

J. Russell Smith. Vantage Press, New York, 1958. 149 pages. $2.75.

"OH YOU DREAMER! What earthly use is astronomy anyway? Why don't you get interested in a practical science?"

Many a young observer of the heavens has had such comments directed his way in past generations. Yet in spite of this, astronomy has always ranked high in the natural interests of children and youth and has provided a priceless hobby to carry into adult life.

Now we suddenly find ourselves in a generation where rockets, satellites, and man-made planetoids put astronomy into a new light — no longer an impractical science or a mere hobby. The man in the street is realizing that astronomy will be for man's exploration of space what geography was for his exploration of the earth. This is a welcome development.

Schools in every part of the country are space conscious. Discussions, lessons, units, and pictures on the space theme are found in most classrooms. This is all quite right and natural — provided the students learn these lessons in their proper setting. Too many classes are doing units on rockets and satellites but becoming little better informed about the universe than they were before.

J. Russell Smith has done the teaching profession a true service by writing this book. It can help teachers in the first nine grades to put their instruction about space into the setting in which it should be, astronomical space. A skilled science teacher and well-known amateur astronomer, the author has had the advice and suggestions of many trained science specialists, educators, and astronomers. Any teacher may use the book with every assurance of its reliability.

Its usefulness as a source for planning activities in astronomy is obvious at a glance. Crisp and complete organization makes both content and method fairly leap from the pages. There are four main parts: the first deals briefly with astronomy in the school, then follow materials for the primary level (grades 1 to 3), the middle grades (4 to 6), and the upper grades (7 to 9).

At each level is presented a clear-cut outline of basic content and major concepts. Then follow scores of practical and appropriate applications, together with full lists of materials, supplies, and other resources.

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edge, there is nothing else like it available. Readers of this review would render their local schools a service by bringing the book to their attention. Indeed each amateur should have a copy for himself, for the things-to-do sections offer many fascinating and practical ideas which can be carried out under the sky itself or indoors on cloudy nights. The lists of books, magazines, charts, maps, and other materials, are very useful.

There is not much to criticize. The main item is on page 76, where the placement of the sun's rays is wrong for the illustration of the phases of the moon. There are no references to satellites and space travel and their relation to astronomy teaching. This should be considered for the next edition.

JOHN STERNIG
Glencoe Public Schools
Glencoe, Ill.

ASTRONOMY

Robert H. Baker. D. Van Nostrand Co., Inc., Princeton, N. J., 1959. 547 pages. $6.95.

OLD BOOKS are nice to have on your library shelves, but if they are old astronomy texts beware of taking their contents too literally. Ours is such a rapidly evolving and expanding science — much like the universe of which it treats — that any textbook more than five years old has become out of date in several respects. Earlier works must be used with some caution.

No one is more aware of this situation than the author of this book that was first published nearly 30 years ago. Robert H. Baker has once again rewritten his famous *Astronomy*, now in its seventh edition. This task has been made easier because the publishers have reset the entire volume, in a more modern type, but its overall character is still unchanged, and Dr. Baker's lucid style marks the new as well as the old sections.

The previous edition appeared four years ago. In rewriting the entire volume, the author has stressed particularly advances in radio astronomy, photoelectric photometry, cosmic and stellar evolution, the magnetism of the galaxy and of stars, and observations with artificial satellites.

One wonders just how, in a case like this, a textbook writer decides what part of the older astronomy is to be left out and what retained. Suppose Dr. Baker had in the earlier editions, when celestial mechanics was seemingly of less general importance than the new astrophysics, curtailed the basic treatment of planetary orbits and gravitational theory. The sudden resurgence of interest in orbit computation spurred by problems of artificial satellites would have necessitated putting such material back into the latest edition. That Dr. Baker has *not* had to do this indicates the soundness of his judgment of what constitutes an introductory course in astronomy. In other chapters as well, it is hard to find what has been omitted without making a sentence-by-sentence comparison with earlier editions.

This is particularly true in what was Chapter 12 in the third edition (1938), and is now Chapter 18. It is entitled, "The Exterior Galaxies," for Dr. Baker has finally come around to this very apt designation for these objects, instead of "The Exterior Systems" of the third edition and "Extragalactic Systems" of the fifth. But in spite of the greater knowledge we now have in this field, in all these editions the chapter is roughly 30 pages long. Thus it retains its relative emphasis in the book's over-all structure.

But there are differences. The galaxies chapter is meatier, containing more facts and less theory, though there are included paragraphs on Gamow's ideas about the origin of the universe, and Hoyle's views on the continuous creation of matter. Back in 1938, the table listing the members of the Local Group of galaxies had eight entries, not including our own system. In the fifth edition, the list had grown to a dozen, and in the latest version there are 16 members in addition to our own.

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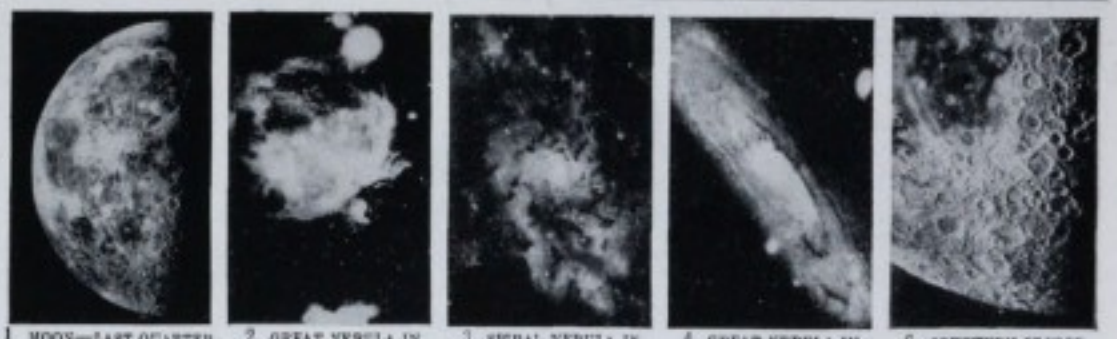
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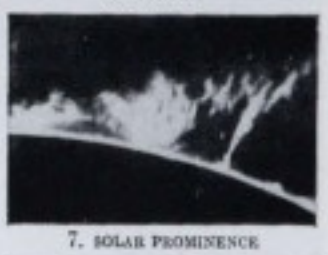
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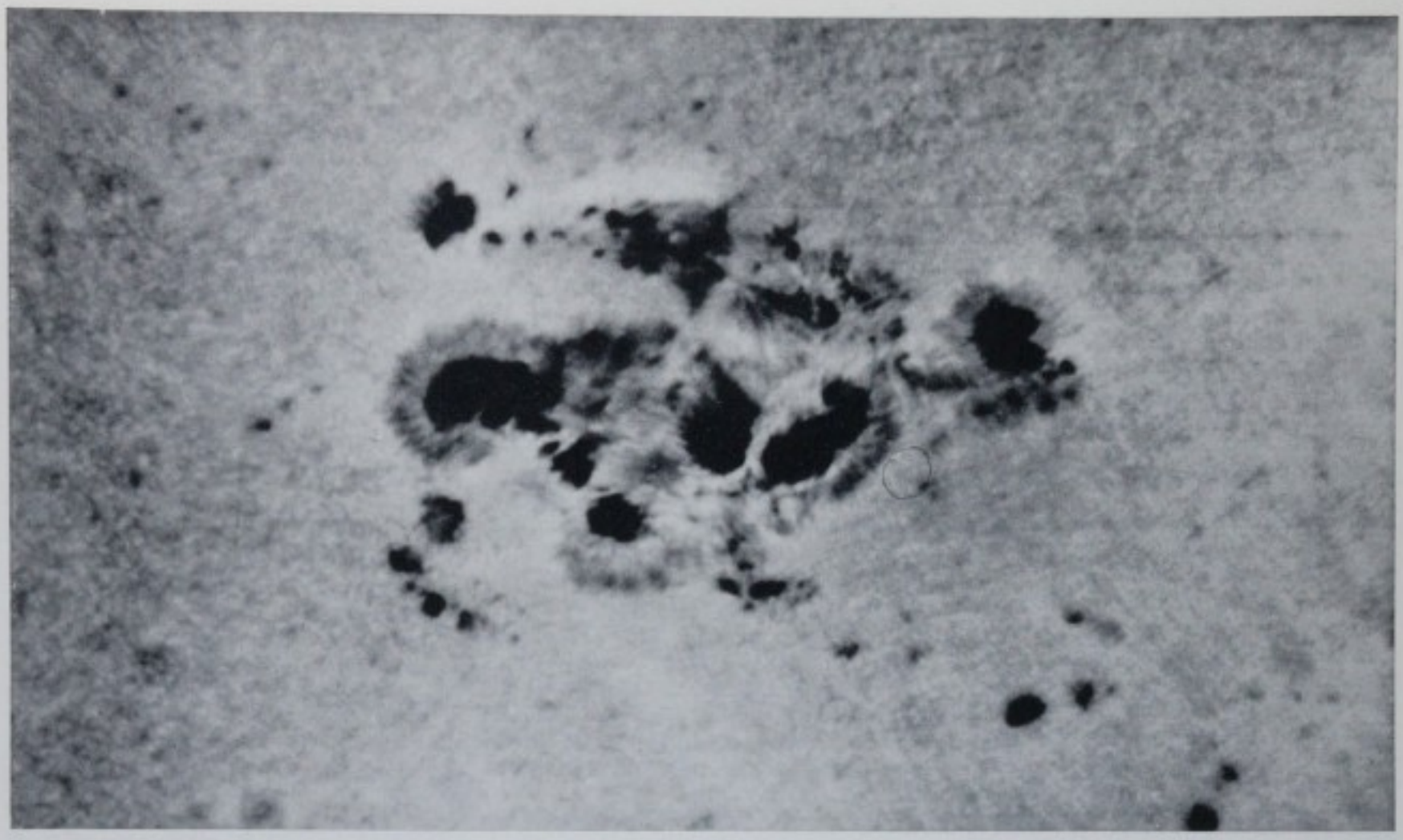

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We think much of Questar's success in achieving these phenomenal pictures is due to its lack of internal tube currents. In this shortest of all telescopes, where lens and mirror are separated by but 6 inches, there is scarcely room for a current to get started. The effective focal length used here was over 50 feet. The photographic print fails to show all of the beautiful intricate tracery so plainly seen in the sunspot on the negative.

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At lower left is a full-aperture filter in its handmade walnut case, while another is attached to the telescope's barrel, in profile here, to show the 6 radial slots of its ventilated cell. This filter may be used with any telescope. Price $150.

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est systems, the others including six dwarf ellipticals and averaging less than 5,000 light-years in diameter.

While the printing of this book is satisfactory, some old engravings need replacing, such as the one on page 16 of the midnight sun. The picture of an annular eclipse on page 155 leaves much to be desired. The Ahnighito meteorite, on page 265, is pictured with Dr. Clyde Fisher in the 77th Street entrance hall of the American Museum of Natural History; it was located there for many years before being moved to the Hayden Planetarium, which was built in 1935. C. A. F.

THE FACE OF THE SUN

H. W. Newton. Penguin Books, Baltimore, Md., 1958. 208 pages. 85 cents, paper bound.

HERE is a very fine paper-back book for the amateur astronomer and interested layman. For it does not contain detailed observing instructions, but rather a wealth of information gathered in all fields of solar astronomy and in solar-terrestrial relationships. The title does not indicate all the subject matter, even though the author deals mostly with sunspots, a field in which this former Royal Greenwich Observatory astronomer is an authority.

In six chapters, the first half of the book presents in detail our knowledge of sunspots and the history of solar observation. Mr. Newton succeeds in enriching the more or less straightforward description of sunspots, their characteristics and the 11-year cycle, with a simple but rewarding touch of human interest. He tells the stories of several of the greatest sunspot groups in a fascinating manner.

The final six chapters are concerned with solar flares, prominences, geomagnetic effects, solar radio waves, the aurorae, and some other solar-terrestrial effects. They conclude with a discussion of the sun as a stellar body.

Today flares are among the most intensively recorded of solar phenomena. These violent yet short-lived "storms" are rivaled only by the enigmatic M-regions that cause profound and extended geomagnetic storms. The M-regions themselves are not visually recognizable, and thus constitute a great problem for solar astronomers.

The book has little to say about the corona, the outermost solar atmosphere that may even envelope our earth, and it tells hardly more about solar radio noise, although great progress has been made in these fields in the last 20 years.

Sixteen pages of photographs and numerous graphs and drawings help make Mr. Newton's book an excellent addition to anyone's library. It has a bargain price.

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NEW BOOKS RECEIVED

THE STRUCTURE AND EVOLUTION OF THE UNIVERSE, *G. J. Whitrow*, 1959, *Hutchinson and Co., Ltd.*, 178-202 Great Portland St., London W. 1, England. 212 pages. 21s.

This is a greatly enlarged revision of the author's *The Structure of the Universe*, which appeared in 1949. Dr. Whitrow describes current views on the nature of space and time, the red shift, the size and age of the universe, and cosmological models. The presentation, which is almost entirely nonmathematical, is intended for the general reader with a scientific background, rather than for the specialist.

BETWEEN EARTH AND SPACE, *Clyde Orr, Jr.*, 1959, *Macmillan*. 253 pages. $4.95.

Climate and weather are described in popular language by a Georgia scientist, who tells about such things as thunderstorms, halos, cloud seeding, radioactive fallout, and satellite exploration of the upper atmosphere. There are 26 photographs.

DESCRIPTIVE METEOROLOGY, *Hurd C. Willett* and *Frederick Sanders*, 1959, *Academic*. 355 pages. $7.50.

Two well-known meteorologists at Massachusetts Institute of Technology have prepared this textbook for a comprehensive college course in introductory meteorology, providing an orderly account of the principal weather phenomena rather than aiming at completeness. For this reason optical and electrical effects of the atmosphere receive only passing mention. This is the second edition of a work that originally appeared in 1944.

RUSSIAN-ENGLISH GLOSSARY OF OPTICS AND SPECTROSCOPY, *I. Emin*, editor, 1959, *Interlanguage Dictionaries Publishing Corp.*, 227 West 17th St., New York 11, N. Y. 78 pages. $10.00, paper bound.

English equivalents are given for about 4,000 technical terms in optics, spectroscopy, and related fields, selected from recent issues of Soviet physical journals.

SEVEN-FIGURE TRIGONOMETRICAL TABLES FOR EVERY SECOND OF TIME, 1958, *Her Majesty's Stationery Office*, York House, Kingsway, London W.C. 2, England. 101 pages. £1.

Astronomers engaged in orbit computation or obtaining star positions from photographs frequently have use for trigonometric tables in which the argument is expressed in hours, minutes, and seconds of time, instead of degrees, minutes, and seconds of arc. The most extensive work of this sort in existence was prepared under the direction of L. J. Comrie of the British Nautical Almanac Office and published in 1938. These seven-place tables are now reissued in photolithographic reproduction, with the four known minor errors corrected.

EVERYDAY METEOROLOGY, *A. Austin Miller* and *M. Parry*, 1959, *Philosophical Library*. 270 pages. $7.50.

This well-written semipopular volume about weather phenomena and their causes will be particularly interesting to amateur astronomers who wish to understand how forecasts can be applied to observing conditions in their own localities. The authors are scientists at the University of Reading in England, and hence their data and examples refer to Great Britain.

SOVIET SPACE SCIENCE, *Ari Shternfeld*, 1959, *Basic Books*. 361 pages. $6.00.

A prominent Soviet space scientist presents a general account, in semitechnical language, of Russian progress and objectives in satellite research, rocketry, and spaceflight. The book is largely devoted to the motions of rockets and artificial satellites, and to problems of rocket construction and propulsion, with secondary consideration given to remote control, radio communications, and physiology.

The author shows wide knowledge of work done in the United States and other countries, thus enhancing the value of the book as a survey of astronautical science to the end of 1957.

ELEMENTARY ASTRONOMY, *Otto Struve, Beverly Lynds*, and *Helen Pillans*, 1959, *Oxford University Press*. 396 pages. $7.00.

Designed primarily as a basic college textbook in astronomy, this book also has special value for the amateur because of its detailed coverage of all current fields.

THE UPPER ATMOSPHERE, *H. S. W. Massey* and *R. L. F. Boyd*, 1959, *Philosophical Library*. 333 pages. $17.50.

Two British geophysicists describe explorations of the upper atmosphere made with radio waves, balloons, rockets, and many other techniques. The phenomena they discuss include radio fadeouts, the ionosphere, aurorae, meteors, and cosmic rays. The book is understandable by laymen who have some scientific background.

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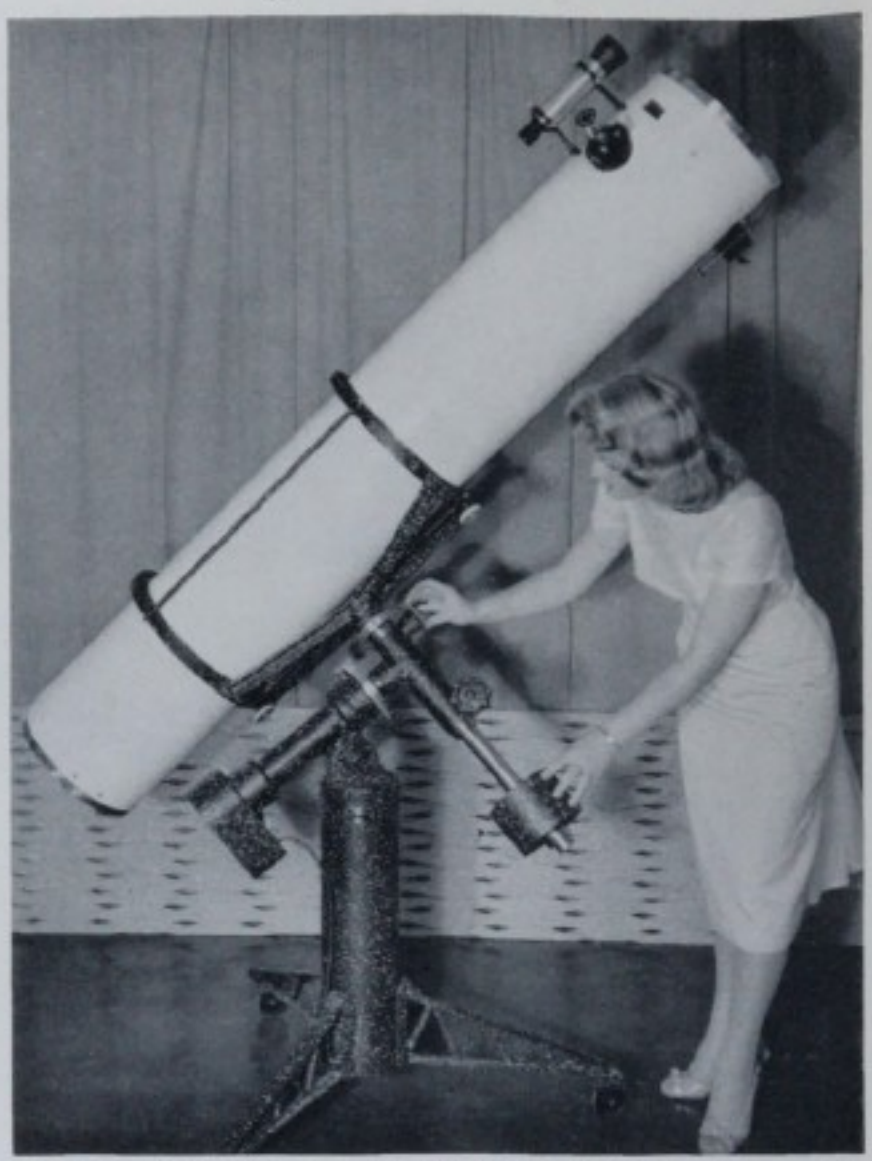

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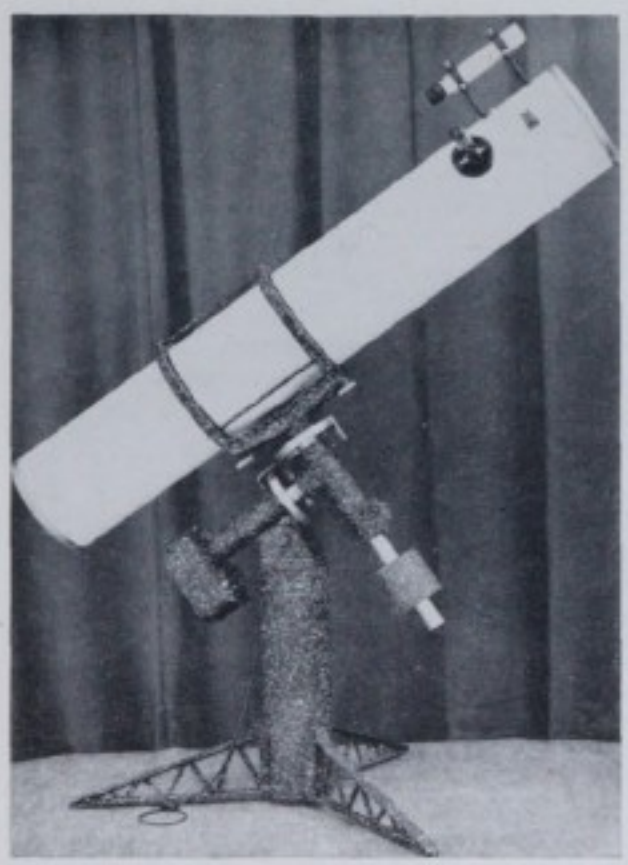

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In the W. C. Cheney Manufacturing Co. shop in Seattle, we have built several metal-melting furnaces, but they are generally too costly and complex for amateur use. Just to see what could be done, however, I have designed the small reverberatory unit pictured here (Fig. 1). The total cost of such a furnace should be between $35 and $50, not counting labor. It requires a minimum of machine work and welding and has proven satisfactory in operation, handling up to 50 pounds of either aluminum or brass.

Why a reverberatory furnace rather than a crucible type, such as the one described in this department by C. Raible some years ago (Sky and Telescope, July-August, 1952)? In a reverberatory furnace the reflected heat is forced back upon the work. This action also results in a quicker conditioning of the lining and reduces the firing and casting time. The metal is less liable to oxidize than in a crucible, and the latter is difficult to handle and lift when hot. A reverberatory furnace is easy to build and operate, so the great majority of foundries use this type.

The Shell. The principal parts of the shell of the furnace are shown in Fig. 2. They are cut from a discarded bottled-gas cylinder of 100-pound capacity with an outside diameter of 15". A damaged tank of this type can be obtained from dealers in my area for from 50 cents to two dollars. The condition of the cylinder (except for dents) is of no importance, as it only furnishes mechanical support for the lining, openings, and supporting bearings.

An oxyacetylene torch is the best tool for cutting up the tank, and can be used afterward to weld the parts. To prevent an explosion of residual gas fumes inside the cylinder, fill it completely with water before using the torch. Set the tank upright on its bottom ring and cut out the valve pad, a round opening 6" in diameter, on the top end. Take care to have this opening as accurately centered as possible.

Measure down about 8" from the top of the tank and slice it off at this point. The water may now be dumped out. A second cut is made on the remaining portion of the cylinder to obtain a bottom section about 16" long. About 1½" from the cut make a round hole 10" in diameter in the straight section of this part, as shown in Fig. 2. The flange at the base of the bottom section is then removed.

From what is left of the cylinder, prepare a strip 4" wide and about 32" long,

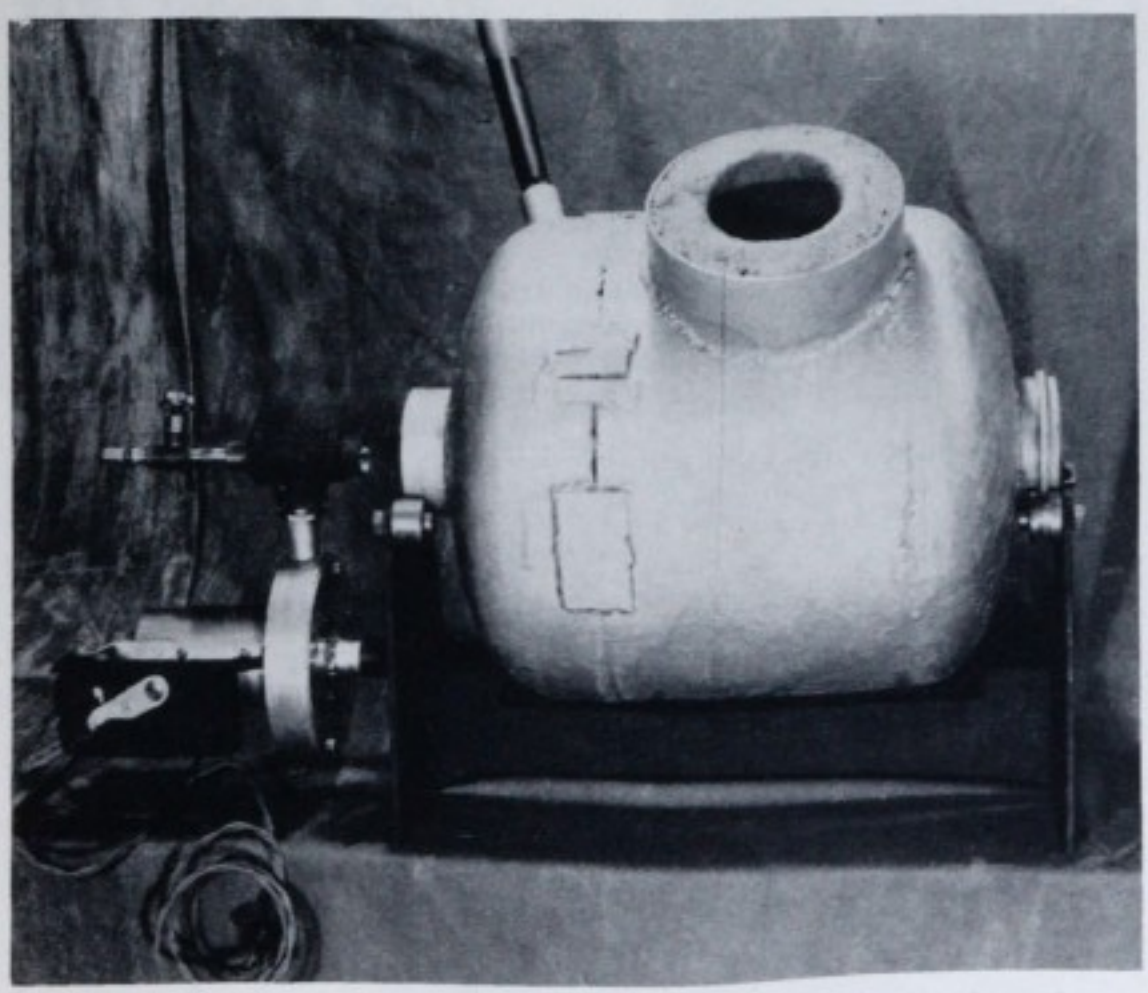

Fig. 1. A reverberatory-type furnace that can be built by amateurs for the casting of aluminum or brass telescope parts. All photographs by the author.

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forming it into a ring that will fit the 10" opening. Three clips, about 3" by 3", are also cut from the surplus stock.

Welding. The lateral seam of the 4" strip is welded first, and the tube thus formed is welded into the 10" hole in the large section of the shell. The three square pieces are equally spaced along the periphery of the short section (Fig. 4), where they will be used to hold the two sections together in the final assembly. A smaller strip may also be attached, as shown in the pictures, to form an aligning piece in the space provided by two similar pieces attached to the large section (Fig. 7).

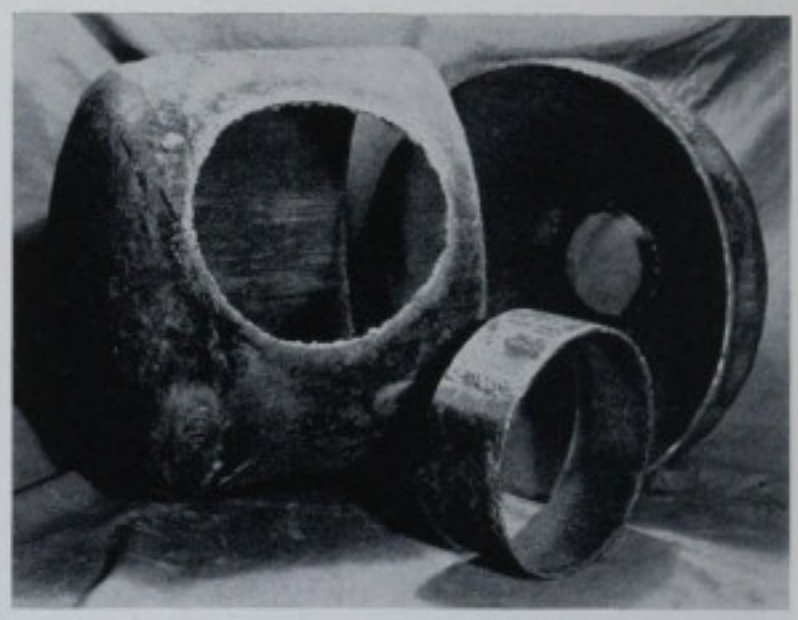

Fig. 2. The three principal parts that are cut from the bottled-gas tank to make the shell of the metal-casting furnace. At left is the 16" bottom section with its 10" hole for the charge-pour opening. On the right the 8" top unit has a 6" flame-port aperture. The 4"-wide ring that frames the charge-pour opening is in front of the other sections.

Next, the hubs on which the furnace will be rotated or tilted are welded on the ends of the two sections. The hub on the short section is smooth and hollow, for it turns on smooth rollers and the fuel enters the furnace through it (Fig. 1). Therefore, it must be carefully centered on the 6" opening. At the other end of the furnace another hub is welded, this one with a raised runner that engages a slot in grooved rollers. Thus, longitudinal movement of the furnace is prevented.

As shown in the lower right-hand corners of Figs. 4 and 5, a length of threaded pipe is welded to the short section. Into this a long piece of pipe can be screwed to form a handle for tilting the furnace during the pouring. Part of the handle is seen at the top of Fig. 1.

Lining the Furnace. Before starting on the interior, procure the four tools shown in Fig. 3. The tamper is essentially a rod about 1" in diameter, 8" long, with a 2" washer welded or fastened on its end. A piece of thin-wall conduit (used by electricians) ½" in diameter or larger is about 16" long. The common trowel is small, with a 4" blade, and the spoon is the large steel kind used by restaurants; cut off about a third of the bowl and sharpen that edge.

The interior of the furnace is the critical part of the construction, and the life of the lining is dependent on how well instructions are carried out. Although there is a wide choice of materials, we use plastic firebrick. It comes in cartons of 100 pounds, about ¾ of a cubic foot. Local distributors can be found in the classified telephone directory under "Fire Brick." Instructions on how to use the material are printed on the carton — *follow them.*

First prepare the small section, placing it on a level surface, secured so it cannot move. Within the hole of the hub at the bottom, block a piece of flat metal plate so it is flush with the bottom of the tank section. Resting on this plate, and concentric with the 6" hole, center an upright piece of 3" pipe. Carefully, so as not to disturb this pipe, start to fill the section with plastic, as shown in Fig. 4.

After about one-third of the lining material is in the section, it should be tamped with the piece of hollow conduit tubing. To avoid pockets, the chunks of plastic need to be sheared past each other — the tube provides the most practical way of doing this. After the section is a little more than full and thoroughly worked with the pipe, push a piece of 6" stovepipe about halfway to the bottom (Fig. 5).

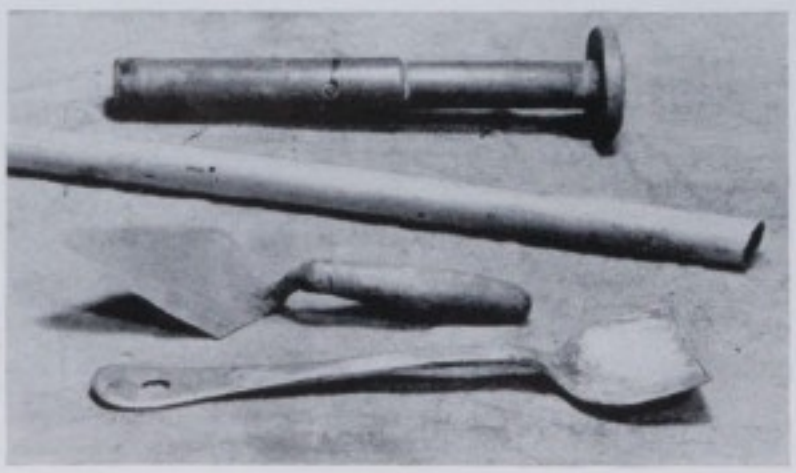

Fig. 3. The tools for shaping and forming the lining of the furnace. In the rear are the tamping rod and the hollow pipe used to pack the plastic firebrick lining into the shell. In front are the trowel and large spoon needed to shape the openings and interior of the furnace.

Illustrated above is the 6" De Luxe Dynascope.

Isn't it time that YOU moved up to this kind of performance?

Ready for the extra thrills that advanced astronomy has to offer? For the kind of observing that is beyond the optical and mechanical abilities of your present equipment? Then you're ready to join the many serious amateurs, schools, colleges, and professional observers who have found the performance they seek in these **custom-built** DYNASCOPES.

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SEE THE SUPERIOR FEATURES YOU GET IN THESE MAGNIFICENT

CUSTOM-BUILT 6" - 8" - 10" - 12" - 16"

DYNASCOPES®

Specifications for 6" model:

- f/9 Parabolic Mirror, accurate to 1/10 wave
- Fully Rotating Tube, for comfortable viewing
- Massive Equatorial Mount, adjustable for your latitude
- 5 Matched 1¼" Eyepieces — 3 Achromatic Ramsdens (45X, 76X, 152X) — 2 Orthoscopics (228X, 343X)
- 8 x 50 Achromatic Finder Scope with crosshairs
- Secondary Support that minimizes diffraction
- Declination Axle, 1½" diameter, with slow motion
- Polar Axle with Needle Bearings on 1½" shaft
- Rack-and-Pinion focusing
- Double-draw Focusing Tube for any eyepiece
- Precision-fashioned 54" Bakelite Tube
- Lightweight Portable Tripod (hidden inside pier of de luxe model illustrated) for field trips
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- Special trade-in terms for present **Dynascope** owners. Write for exact allowances, describing present model and condition. Easy payment plans also available.

ONLY $265 FOR THIS SUPERB 6-INCH STANDARD DYNASCOPE®

Also illustrated: Electric Clock Drive, $80; Setting Circles, $60; Permanent Pedestal, $70. Write today for full specifications and details of these superior reflecting telescopes.

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If you are interested in exciting, exacting performance at reasonable cost, this standard 4-inch **Dynascope** offers value unduplicated among other popular-priced reflectors of its size.

The advanced design of this precision-made instrument includes all the professional-type features essential for superior viewing — some so new that they were not even available on our more expensive **Dynascopes** just a year or so ago. Constructed of the finest quality materials, each component is skillfully engineered for dependable operation and fully finished for attractive modern appearance. And, in the true **Dynascope** tradition, this thrifty 4-inch model brings you all the superior advantages of Criterion's superb optical system, as described in this advertisement.

You can order this rich-looking reflector with complete confidence that it will deliver all the performance it promises. Twice-tested to U. S. Government standards before it leaves our factory, it must also meet **your** test of satisfaction or you may return it for full refund. Send check or money order today for prompt delivery.

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- **Classic 4-inch parabolic pyrex mirror** guaranteed to perform to Dawes' limit for its size. Aluminized and coated with zircon quartz.
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- **4-power crosshair finderscope** with coated achromatic lenses, for greater accuracy, easier spotting. Screw-type micrometer focus. Extra-large field of view. (Double-posted bracket with collimation adjustments.)
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- **3 compound eyepieces:** 18-mm. Huygens, 9-mm. Achromatic Ramsden, 7-mm. Achromatic Ramsden, for 65X, 130X, 167X. Completely threaded precision units. Clear, sharp views to extreme edges.
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Complete including sturdy steel tubular tripod designed to solve all stability problems. No canting, wobble or side play. Special position locks prevent collapse. Completely portable, sets up instantly on uneven terrain. Folds up without disassembling.

Special Introductory Offer $79.95 f.o.b. Hartford Wt. 26 lbs.

Enjoy effortless, automatic tracking at modest cost! New Dyn-o-matic electric drive lets you devote your **entire attention** to viewing. Self-acting clutch engages and disengages drive without pause as you seek different objects. Completely enclosed. A.C. 110/120, 60-cycle synchronous motor.

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MODEL NO. ED-460

CRITERION Manufacturing Co.

Manufacturers of Quality Optical Instruments

Dept. STD-57, 331 Church St., Hartford 1, Conn.

Fig. 4. The small section partially filled with plastic firebrick prior to tamping with the pipe tool.

Then, with the tamper, press the plastic firebrick very well – not lightly, but *hard*.

Remove the stovepipe and 3″ tube and use the sharpened spoon to smooth and mold the plastic until it looks like Fig. 6. It will help to dip the spoon in clean water frequently. Use the trowel to trim and smooth the top surface, but allow it to extend about ¼″ above the edge of the metal shell.

The large section of the furnace is handled in much the same way, giving the final appearance of Fig. 7. First place a 6″ layer of plastic against the bottom of the tank and tamp it well with the conduit tube. Then place the 6″ stovepipe in the center, forming the furnace's interior space. The same size of stovepipe is also placed in the 10″ ring on the side of the section, thus forming the opening through which the charge is loaded and out of which it is poured after being melted.

To insure a long life for the furnace, plenty of time should be spent in tamping with the conduit pipe and with the solid tamper. If this work is done well, the lining may last from 1,000 to 3,000 hours of firing.

Tank Assembly. The two sections are now ready to be assembled. Take a handful of the plastic liner and mix it with water until it has the consistency of thick

Fig. 5. Firm tamping with the rod is essential at this stage.

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Enjoy the advantages of a compact Cassegrain telescope
Get high performance with Cal-Astro matched optics

These fine mirrors are first figured individually to close tolerances, then set up together and retouched as a unit in order to remove every trace of residual spherical aberration from the system.

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Here is a combination of a Barlow and a particular ocular which gives outstanding results. It consists of our new Barlow and our 16.3-mm. (⅔″ focal length) Erfle eyepiece. While the Barlow was not specifically designed to work with this eyepiece, it does so to an astonishing degree. All images are sharp and hard to the very edge of the field.

The Barlow gives magnification up to slightly over three times that of the ocular alone. It is achromatic, coated, and mounted to the U. S. standard size of 1.250 inches.

The modified Erfle eyepiece has a field of 75 degrees with excellent eye relief. The combination gives the equivalent focal length of slightly under 6 millimeters. Many users state it is far superior to any shorter focal length ocular of equivalent magnification.

The Barlow sells for $16.00 postpaid, and the Erfle for $14.75 postpaid. Both are guaranteed to perform as stated above or money refunded.

ORTHOSCOPIC OCULARS—All hard coated, standard 1¼-inch outside diameter.

28-mm.	$15.00	10.5-mm.	$16.25	4-mm.	$17.25
16.3-mm. (Erfle)	$14.75	7-mm.	$17.25	Barlow 3x	$16.00

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Write for quotations on special curves or crystalline materials, if high precision is required.

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I will be pleased to send, upon request, a fuller, illustrated description of my work, together with some suggestions on the construction and use of the reflecting telescope which are based on long experience and association, and which may help in getting the best performance from an instrument under various conditions.

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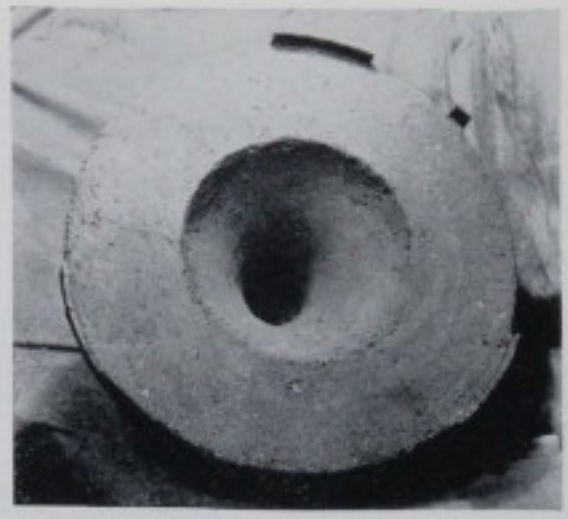

Fig. 6. The specially shaped lining of the small section. The large spoon is needed to form this portion.

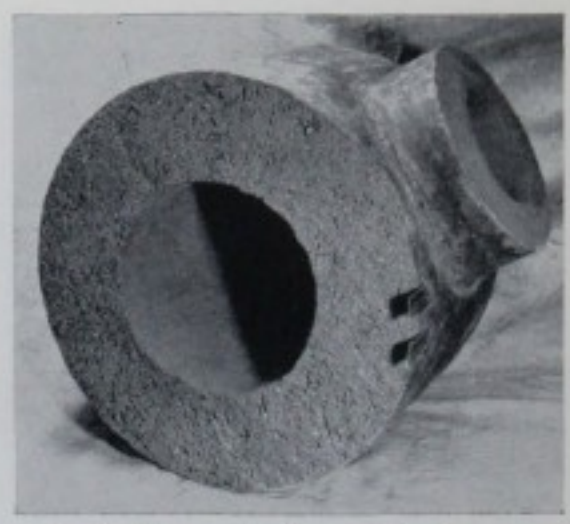

Fig. 7. The main body of the furnace. Both the central opening and the charge-pour hole have a 6" diameter.

cake batter. Spread this material evenly over both faces, press them firmly together and immediately tack-weld the three clips to the large section.

Curing the Lining. The final step before operating the furnace is to dry out the considerable amount of water that is in the plastic, a slow process. With the charge-pour opening at right angles to the floor, place a 150-watt lamp in the furnace interior and permit it to burn constantly for a week or 10 days. At the end of that time, build a small wood fire in the furnace and keep it burning slowly for about eight hours. The unit should then be ready for its first charge.

Support and Burner. The design of the support for the furnace is largely a matter of individual ingenuity. It is important, however, to make allowance for thermal expansion and to use rollers and frame members that are substantial enough to bear the considerable weight of the furnace and the charges of metal.

Next month we shall discuss the burner unit, seen at the left in Fig. 1. It can be built to specifications to operate on any of three basic fuels: oil, bottled gas, and natural gas. Examples of castings made in simple molds and of finished products from these castings will be shown.

WILLIAM CHENEY
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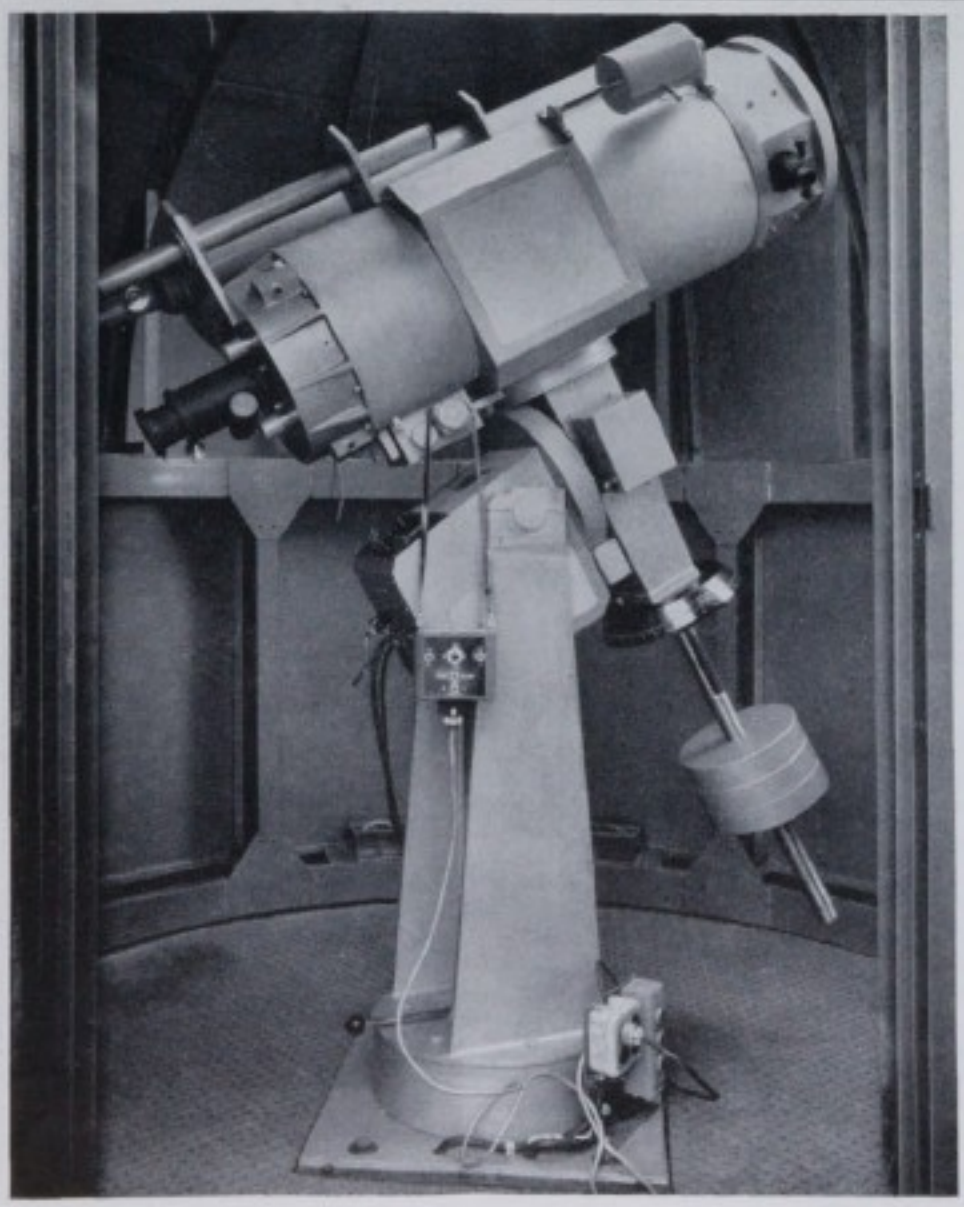

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TINSLEY LABORATORIES has installed, at Ames Observatory in Texas, this astronomical telescope with a special attachment to track future, distant satellites. The combination Newtonian-Cassegrainian reflector, designed and manufactured by Tinsley, has a 12-inch aperture and weighs about 1,000 pounds. Seven motors are incorporated into the telescope; a combination of three motors gives any rate from star speed to satellite speed. The entire mechanism is mounted on a hydraulic lift, to raise or lower it for easy observing.

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Now you can build a fine instrument like this, easily and at low cost, with matched parts by Cleveland Astronomics

This high-quality astronomical telescope was developed for Cleveland Amateur Telescope Makers by professional designers. The results were so successful that we are now making the parts available to amateurs everywhere. It was designed with three purposes in mind: first, a portable telescope equal or superior in quality to any 6-inch reflector available; second, low cost for the amateur's budget; third, matched parts for easy assembly, and standardized accessories that can be added at any time.

Cleveland Astronomics supplies everything you need except mirrors and eyepieces. All parts and accessories are machined to close tolerances to fit together accurately. You can assemble the complete telescope with a screwdriver and wrench.

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The new Cleveland Equatorial Mount gives your portable telescope the stability of a permanent mount. The built-in features described below mean better performance and more enjoyable observing.

1 Rotating base permits you to set up anywhere, then easily align and lock the polar axis on north. Makes accurate locating and tracking much easier.

2 Quick-adjusting, positive-locking tube clamp with concealed stop permits rotation of tube in saddle, keeps tube in correct balance, prevents sliding.

3 Husky, vise-grip latitude adjustment is easy to change, stays where you put it. We set it to your latitude before shipping.

4 Rigid, high-strength aluminum construction eliminates excessive weight, prevents rust.

5 All parts accurately machined to close tolerances for smooth, trouble-free operation. Designed for easy addition of accessories.

6 Accurately ground and polished steel axles, extra-long bearings and large brakes provide free movement and precise control.

7 Sturdy, cast-aluminum, tapered channel legs open to fixed position, require no folding braces. Close easily for carrying.

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Acme threaded brass sleeve in cast-aluminum housing gives you smooth, micrometer-sharp focusing. Only one moving part. **$7.95 ppd.**

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Just what you need for comfortable viewing at night. Fits any telescope. Takes one size-D flashlight battery. Case has wing nut and clamp for fastening to tripod leg. Complete with two 50" cords, each with grain-of-wheat lamp and housing at the end. One lamp is controlled for brightness by a rheostat at the top of cell. By drilling small hole in finder tube at the plane of reticle, you can illuminate crosshairs to see them clearly at night. The rheostat will give you just the brightness you need. The other cord and lamp, which stays at same brightness all the time, can be used to illuminate your setting circles, to see which eyepieces you are using, to look at charts, or to make notes. We are really enthused about this item, and you will be, too. This is brand new.

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This model uses rolls of #127 film. Picture area will be a circle 1-9/16" in diameter.

The advantage of this model is the ease of using roll film. With each camera you get a piece of ground glass. Before loading film in the camera, you focus the telescope. Then lock it in this position. For positions other than infinity, you can scribe a mark on your tube.

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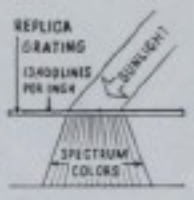

It's here — after decades of effort! Replica grating — on film — at very low price. Breaks up white light into full spectrum colors. An exciting display. 13,400 lines per inch. Spectrographs have been used to answer more questions about the structure of the material world and the universe than any other single device. Use it for making spectroscopes, for experiments, as a fascinating novelty. First time available in such a large size — so cheaply. Comes in clear plastic protector.

Stock #50,202-Y....Includes 2 pieces, 6" x 5½" — 1 transmission type, 1 reflection type....$2.00 ppd.

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Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

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50,051-Y	4¼"	45"	⅝"	15.00 ppd.
70,168-Y	6"	72" (Pyrex)	1"	30.00 ppd.

PARABOLIC MIRRORS (Pyrex)

No.	Diam.	F.L.	Thickness	Price
5002-Y	6"	48"	1"	$59.50 ppd.
85,069-Y	8"	64"	1⅜"	89.00 f.o.b.*
85,070-Y	10"	80"	1¾"	179.00 f.o.b.*
85,071-Y	12½"	100"	2⅛"	275.00 f.o.b.*

*F.o.b. Barrington, N. J.

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Here is a de luxe finder that is very impressive. The telescope part is our regular 5.5-power Moonwatch satellite scope with crosshairs added. The exceptionally large 12° field plus its excellent light-gathering power make this an excellent finder telescope. In addition, you can always take it off for satellite viewing. Twin-ring finder mount is included and makes it easy to center the scope. Can be mounted on tubes of various sizes.

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An excellent lens — can be adapted for use on 35-mm. and Speed Graphic cameras as a telephoto lens. Three of the first four pictures of Sputnik III were taken by a student with a homemade camera using one of these lenses. Adjustable diaphragm, f/16 to f/2.5. Gov't. cost over $400. War surplus.

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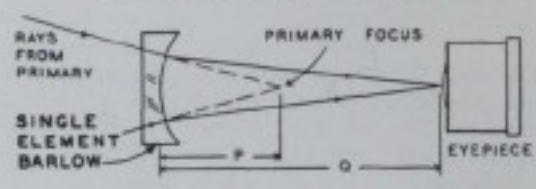

WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Stock #30,200-Y Mounted Barlow lens.....$8.00 ppd.

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The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

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Mounted Kellner Eyepiece, Type 3, 2 achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

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Used; $59.50 New

Mounted in beautiful brass cells, lenses are 4"-diam. precision 4-element type, Aero Tessar and Aero Ektar. Housed in cone — focal plane 10" beyond cone and permits building on a filmholder, eyepiece, etc. Lenses are easily removed for other uses. Diaphragm included — adjusts by flexible rod (easily extended) from f/6 to f/22. Opens approx. 1" to 3½". Lens and cone weigh 25 lbs. Sturdy carrying trunk weighs 26 lbs.

USES: 1. For long-range, Big Bertha telephoto lens. 2. For rich-field (wide-field, low-power) telescope. 3. As opaque projector lens. 4. In Operation Phototrack (photographing artificial satellites).

Stock #85,059-Y.....**24", used**.....**$39.50** f.o.b. Utah

Stock #85,060-Y.....**24", new**.....**$59.50** f.o.b. Utah

Send check or money order — Money-back guarantee.

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Two 8"-diam. dials accurately printed on 1/16"-thick black plastic, rigid and unbreakable. White figures on black background. Alternate black-and-white blocks designate divisions, allow easier reading — less eyestrain. ¼" pivot hole in center. Declination circle has 360° divided into 1° intervals, and reads from 0 to 90 to 0 to 90 to 0. Right-ascension circle has 24-hour scale divided into 5-minute blocks with two different scales on the same side. One reads from 0 to 6 to 0 to 6 to 0 hours and the other 1 to 24 hours consecutively. Instruction sheet included.

Stock #50,133-Y....Complete set.....**$3.00 ppd.**

Stock #60,078-Y....360° declination circle only **$1.60 ppd.**

Stock #60,079-Y....24-hour right-ascension circle only **$1.60 ppd.**

5¾" SETTING-CIRCLE SET

Same as described above but with 5¾"-diam. dials.

Stock #50,190-Y....Complete set.....**$2.50 ppd.**

Stock #60,080-Y....360° declination circle only **$1.35 ppd.**

Stock #60,081-Y....24-hour right-ascension circle only **$1.35 ppd.**

EQUATORIAL MOUNT and TRIPOD with CLOCK DRIVE

Heavy-duty mount. Drive operates on 110-volt, 60-cycle, a.c. house current. Follows motion of stars smoothly. 32" tripod legs included.

Stock #85,081-Y.....**$76.50** f.o.b. Barrington, N. J.

Same mount as above, without clock drive, for 8" or smaller reflectors and for 4" or smaller refractors.

Stock #85,023-Y.....New Low Price.....**$39.50** f.o.b. Barrington, N. J.

MOTORIZED CLOCK DRIVE (by itself) easily attached to your own mount. Instructions included.

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Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅜" I.D. and our 3⅜" I.D. aluminum tubes respectively.

For Reflectors

Stock #50,077-Y (less diagonal holder) **$8.50 ppd.**

Stock #60,049-Y (diagonal holder only) **1.00 ppd.**

For Refractors

Stock #50,103-Y (for 2⅜" I.D. tubing) **12.95 ppd.**

Stock #50,108-Y (for 3⅜" I.D. tubing) **13.95 ppd.**

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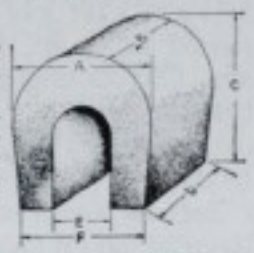
Stock #70,173-Y.....**$13.50 ppd.**

GIANT MAGNETS! TERRIFIC BARGAINS!



War surplus — Alnico V type. Horseshoe shape. Tremendous lifting power. 3 lb. size. Its dimensions: A — 3⅛"; B — 2¾"; C — 4-3/16"; D — 1¼"; E — 1⅛"; F — 2⅝". Strength is about 2,000 Gauss. Will lift over 125 lbs.

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15¾-lb. size magnet. Approximately 5,000-6,000-Gauss rating. Will lift over 250 lbs.

Stock #85,088-Y ..... **$22.50** f.o.b. Barrington, N. J.

Shipping wt. 22 lbs.

STANDARD 1¼" EYEPIECE HOLDER

Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y.....**$2.50 ppd.**

PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y.....**$12.00 ppd.**

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Stock #30,265-Y.....**$3.50 ppd.**

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Stock #30,266-Y.....**$5.50 ppd.**

Sale! GIANT ERFLE EYEPIECE

Here is an exciting bargain. We have obtained a large lot of these eyepieces reasonably — so down goes the price to $9.95 for a real sale. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this lot is all sold, and triple and quadruple as years pass. If we didn't need to reduce our inventory, we'd be tempted to hold onto these eyepieces. Their wide apparent field is 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads; focusing adapter with 32 threads per inch is included; diameter is 2-11/16". If you don't order now and you miss out on a hundred-dollar eyepiece for only $9.95, you can't say that we didn't try to impress you with its value. You can make some super-duper finders with these eyepieces. They are also ideal for rich-field telescopes, which are becoming more popular daily, particularly in the Sputnik age. Everyone with a large reflecting telescope should have one of these.

Stock #50,178-Y.....**Sale Price $9.95 ppd.**

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CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

Venus To Occult Regulus

A CELESTIAL PHENOMENON so rare that there is no definite record of an earlier occurrence will take place on July 7, 1959, when Venus passes in front of the 1st-magnitude star Regulus. The event will occur during daylight for watchers on the east coast of North America, in South America, Europe, and Africa; only in southern Asia can it be seen in a dark sky.

On that date, Venus is two weeks past greatest eastern elongation, its disk being 41-per-cent illuminated and 28.5 seconds of arc in diameter. The planet is moving east and south, at the rate of one diameter in 12.7 minutes of time. The disappearance of the star takes place at the dark limb, the reappearance at the illuminated edge of the −4.1-magnitude planet.

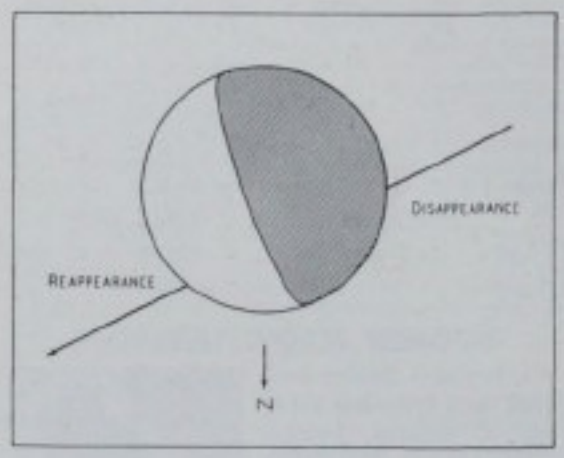
The circumstances of the occultation for Washington, D. C., are typical for locations along the Atlantic seaboard. Regulus will be covered by Venus from 10:15 a.m. to 10:27 a.m., Eastern daylight time. When the occultation begins, the planet will be only 8° above the eastern horizon, and considerably lower than the sun. Under these unfavorable conditions, an amateur will probably need a very clear sky and a fairly large telescope to make a satisfactory observation. Even a slight amount of haze may make Regulus invisible, although of magnitude +1.3.

In the January, 1959, *Journal* of the British Astronomical Association, Gordon E. Taylor published the following predictions for six places. In addition, he gave data for Montreal in the *Observer's Handbook* of the Royal Astronomical Society of Canada.

Station	*Disappearance U.T.*	*P.A.*	*Reappearance U.T.*	*P.A.*
Montreal, Canada	14:15	93	14:27	323
Washington, D. C.	14:15	93	14:27	323
La Plata, Argentina	14:20	163	14:31	254
Greenwich, England	14:21	66	14:30	349
Algiers, Algeria	14:21	82	14:32	333
Cape of Good Hope, South Africa	14:25	139	14:38	276
Hyderabad, India	14:30	57	14:37	359

In this table, *P.A.* is the position angle of Regulus with respect to the center of Venus. This angle is counted from 0° at the north point of the planet's disk through the east point.

Amateurs whose telescopes are not equipped with setting circles can use the following method to locate Venus in the daytime sky. The 4th-magnitude star Lambda Tauri has practically the same declination (being only 10′ farther north), and therefore its sky position is very closely that which Venus will have six hours and seven minutes later. If the telescope is pointed at Lambda Tauri at



On July 7, 1959, Venus will occult Regulus, an event that will be visible in the morning sky shortly after 10 a.m., Eastern daylight time, for observers on the East Coast. The motion of Venus will produce the illusion of Regulus moving, shown by the diagonal arrow. The star goes behind the dark limb of the planet.

3:53 a.m. EDT *and left unchanged,* Venus should be in the field of view at 10:00 a.m. EDT, a quarter hour before the occultation begins in North America. For this method, a low-power eyepiece should be used.

Because Venus has a dense atmosphere, Regulus should disappear gradually. Careful observations of the nature of the fading, and of the time when the last trace of the star vanishes, should provide valuable information concerning the planet's atmosphere.

OCCULTATION PREDICTIONS

June 10-11 **Alpha Cancri** 4.3, 8:56.2 +12-01.1, 5. Im: **I** 5:29.6 0.0 −1.8 112.

June 21-22 **Rho Sagittarii** 4.0, 19:19.3 −17-55.7, 16. Im: **A** 3:38.8 −1.5 +1.8 51; **B** 3:43.0 −1.4 +2.0 45; **C** 3:25.7 −1.4 +1.7 61; **D** 3:31.3 −1.3 +2.0 52. Em: **A** 4:41.2 −1.7 0.0 298; **B** 4:39.3 −1.5 −0.1 304; **C** 4:33.2 −1.7 +0.3 289; **D** 4:30.7 −1.4 +0.2 299; **E** 4:14.9 −1.1 +0.7 286; **F** 3:59.2 −1.0 +1.2 260.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the British *Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo**−**LoS**), and multiply **b** by the difference in latitude (**L**−**LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

MOON PHASES AND DISTANCE

New moon	June 6, 11:53
First quarter	June 14, 5:22
Full moon	June 20, 20:00
Last quarter	June 27, 22:12
New moon	July 6, 2:00

	June	*Distance*	*Diameter*
Apogee	4, 8h	252,500 mi.	29′ 25″
Perigee	19, 13h	223,500 mi.	33′ 14″
	July		
Apogee	1, 19h	252,000 mi.	29′ 28″

MINOR PLANET PREDICTIONS

Harmonia, 40, 9.2. June 1, 18:59.1 −22-09; 11, 18:52.6 −22-38; 21, 18:43.5 −23-12. July 1, 18:32.8 −23-45; 11, 18:22.0 −24-15; 21, 18:12.7 −24-40. Opposition on June 30.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

June 1, 18:14; 4, 15:02; 7, 11:51; 10, 8:40; 13, 5:29; 16, 2:18; 18, 23:06; 21, 19:55; 24, 16:44; 27, 13:32; 30, 10:21.

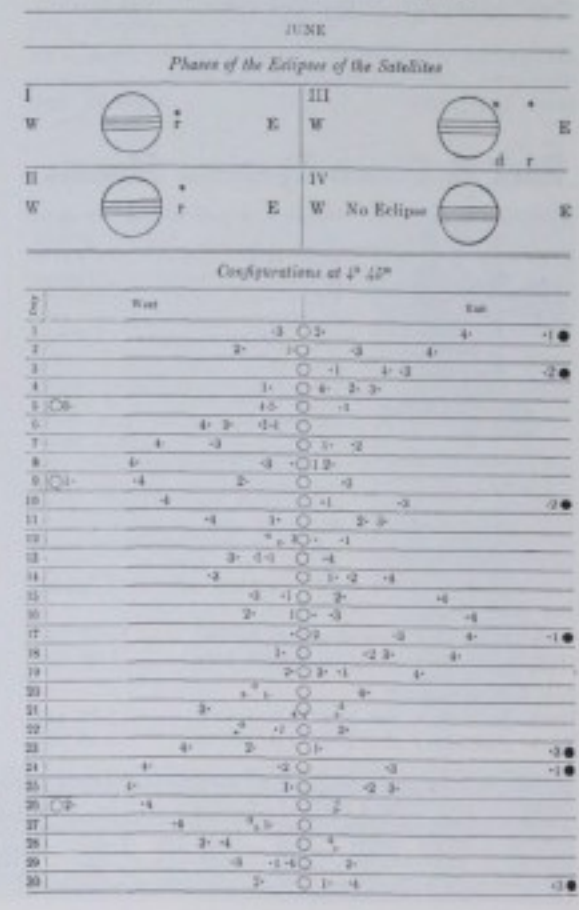
July 3, 7:10; 6, 3:58; 9, 0:47; 11, 21:36; 14, 18:24.

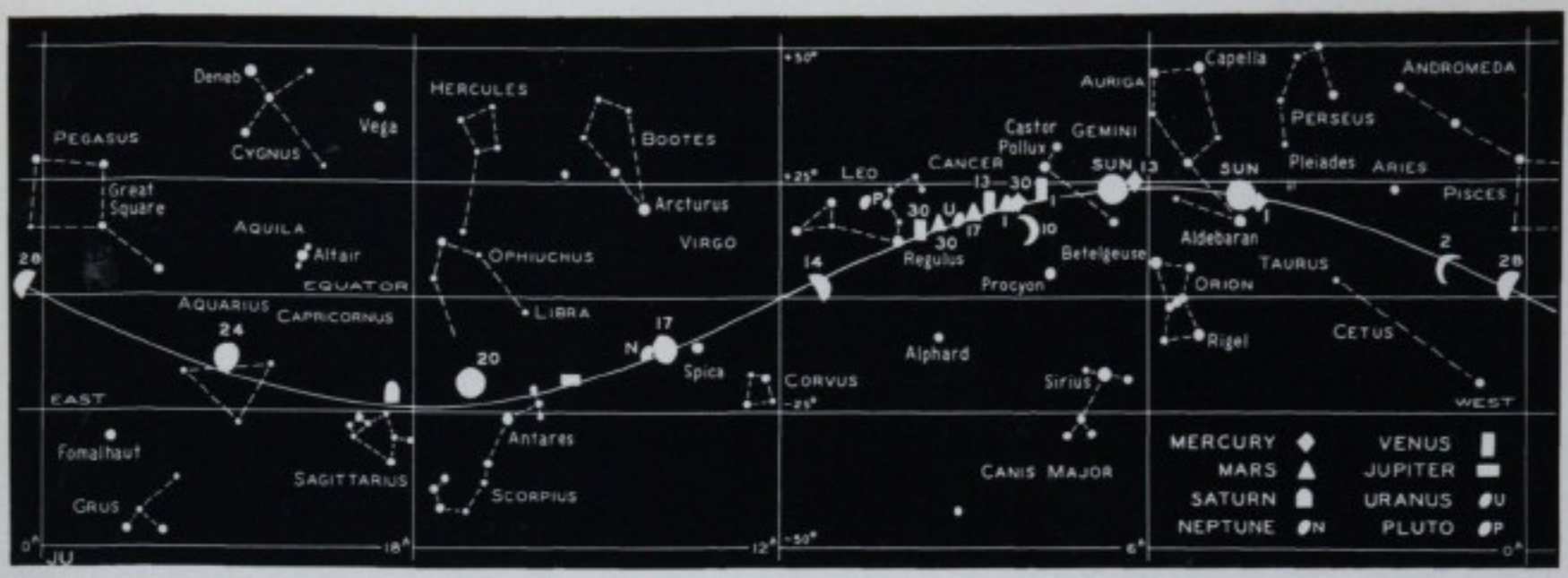
These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from *The American Ephemeris and Nautical Almanac.*





THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other days shown. All positions are for 0^h Universal time on the respective dates.

Mercury is in superior conjunction with the sun on June 3rd, and remains too near it to be seen until the latter part of the month. On the 25th Mercury will be of magnitude 0, visible low in the west an hour after sunset.

Venus is a brilliant object, located near the Beehive cluster in Cancer during the middle of the month. It is then of magnitude −3.9, setting about three hours after the sun. Telescopically, it shows a disk almost at quarter phase, 54-per-cent illuminated and 21″.8 in diameter. Greatest eastern elongation comes on the 23rd, with Venus 45° 25′ from the sun.

Earth reaches heliocentric longitude 270° on June 22nd at 3:50 Universal time. This is the solstice, marking the beginning of summer in the Northern Hemisphere and winter in the Southern. Earliest sunrise is on June 14th, latest sunset on the 26th, in latitude 40° north.

Mars on the 15th is in Cancer near Venus, setting about three hours after the sun. On this date it is at magnitude +1.9. The moon will be near both planets on the evening of the 10th, and on June 14th, at 13^h UT, Venus will pass north of Mars, the minimum separation being 51′.

Jupiter is in Libra, of magnitude −2.0, well up in the southeast at sunset and crossing the meridian about two hours later. In a telescope the planet's slightly flattened disk has an east-west diameter of 44″ and a north-south diameter of 41″. The moon will pass 2½° north of Jupiter on the morning of June 18th.

Saturn will reach opposition to the sun on the 26th, 842 million miles from the earth. It rises about sunset, and is visible all night in Sagittarius as an object of magnitude +0.3. A telescope will show the disk of the planet, 16″ in diameter, and the ring system, 41″ in extent. The moon will pass about 4° north of Saturn on the evening of the 20th.

Uranus is moving very slowly eastward in Cancer. On June 15th its right ascension is 9^h 04^m.3, declination +17° 26′ (1950 co-ordinates). This 6th-magnitude planet is easily seen in binoculars. Venus will be close to Uranus on the evening of June 19th, passing about 1¼° north at 3^h UT on the 20th. On June 24th at 0^h UT, Mars will be located only 39′ north of Uranus.

Neptune is in eastern Virgo, at 14^h 10^m.7, −11° 15′ (1950), on the 15th of June. Telescopically, this distant 8th-magnitude planet shows a tiny greenish disk 2″.5 in diameter.

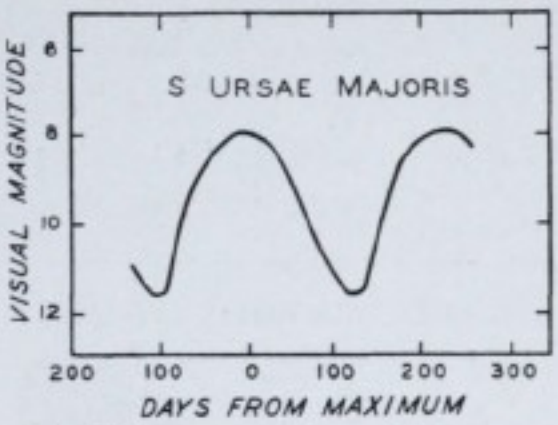
W. H. G.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours, respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.

S URSAE MAJORIS

WHEN it attains maximum brightness about the middle of this month, the star S Ursae Majoris will be conveniently placed for observation. This is one of the earliest known long-period variables, and also one of the most intensively observed. Its variability was discovered at Radcliffe Observatory, Oxford, England, from



The light curve of the variable star S Ursae Majoris, determined by the American Association of Variable Star Observers. Mean maximum is 7.9, mean minimum 11.6. From "Studies of Long Period Variables," by Leon Campbell.

discordant magnitudes recorded during meridian-circle observations in 1843-44.

The accompanying light curve was compiled by Leon Campbell from many years of observations by members of the American Association of Variable Star Observers. It represents the average behavior of the star, whose maximum light has been in recent years as bright as magnitude 7.4 and as faint as 8.1. In this average curve some features that do not occur in every cycle, such as the hump 1½ months before maximum, tend to be smoothed out. The average period of S Ursae Majoris is 226.1 days, and its spectrum is of type *S* rather than *M*, which is much commoner among long-period variables.

The 1950 position of this reddish yellow star is 12^h 41^m.8, +61° 22′, not far from the Big Dipper stars Delta and Epsilon Ursae Majoris, with which it forms a nearly equilateral triangle. Care should be taken to avoid confusing the variable with a 7th-magnitude star 0^m.9 west of it and 4′ north.

VARIABLE STAR MAXIMA

June 5, S Carinae, 100661, 5.7; 6, T Centauri, 133633, 6.1; 8, T Herculis, 180531, 8.0; 10, RR Scorpii, 165030, 6.0; 11, R Corvi, 121418, 7.6; 11, S Ursae Majoris, 123961, 7.9; 17, R Carinae, 092962, 4.6; 18, U Ceti, 022813, 7.5; 30, T Columbae, 051533, 7.6.

July 2, R Caeli, 043738, 8.0; 2, V Ophiuchi, 162112, 7.5; 5, R Pegasi, 230110, 7.9.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

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Each lens is thoroughly tested by us and is guaranteed to resolve two seconds of arc or better. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cell is machined to close tolerances so that it will fit directly over our standard aluminum tubing, eliminating any mounting problems.

3¼" diam., 48" F.L. (uncoated) **$28.00**
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Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm. (2⅛")	254 mm. (10")	$12.50	83 mm. (3¼")	660 mm. (26")	$28.00
54 mm. (2⅛")	300 mm. (11.8")	12.50	83 mm. (3¼")	711 mm. (28")	28.00
54 mm. (2⅛")	330 mm. (13")	12.50	83 mm. (3¼")	762 mm. (30")	28.00
54 mm. (2⅛")	390 mm. (15.4")	9.75	83 mm. (3¼")	876 mm. (34½")	28.00
54 mm. (2⅛")	508 mm. (20")	12.50	83 mm. (3¼")	1016 mm. (40")	30.00
54 mm. (2⅛")	600 mm. (23½")	12.50	102 mm. (4")	876 mm. (34½")	60.00
54 mm. (2⅛")	762 mm. (30")	12.50	108 mm. (4¼")	914 mm. (36")	60.00
54 mm. (2⅛")	1016 mm. (40")	12.50	110 mm. (4⅜")*	1069 mm. (42-1/16")	60.00
54 mm. (2⅛")	1270 mm. (50")	12.50	110 mm. (4⅜")	1069 mm. (42-1/16")	67.00
78 mm. (3-1/16")	381 mm. (15")	21.00	128 mm. (5-1/16")*	628 mm. (24¼")	75.00
80 mm. (3⅛")	495 mm. (19½")	28.00	128 mm. (5-1/16")	628 mm. (24¼")	85.00
81 mm. (3-3/16")	622 mm. (24½")	22.50	*Not coated		

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Beautiful imported binoculars, precision made, at a low, low price. Above we have pictured the two most popular types. The American Type offers a superior one-piece frame and a clean design, pleasing to the eye. Complete with carrying case and straps. **Price plus 10% Federal tax.**

Size	Field at 1,000 yards	Type	Center Focus	Ind. Focus
6 x 15	360 ft.	Opera	—	$12.75
6 x 30	395	"Zeiss"	$18.75	16.75
7 x 35	341	"Zeiss"	20.75	17.95
7 x 35	341	American	23.50	—
7 x 35	578	American Wide Angle 11°	35.00	—
7 x 50	372	"Zeiss"	24.95	22.50
7 x 50	372	American	32.50	—
8 x 30	393	"Zeiss"	21.00	18.25
10 x 50	275	"Zeiss"	28.75	26.75
20 x 50	183	"Zeiss"	33.75	31.75

MONOCULARS

Brand new, coated optics, complete with pigskin case and neck straps.

	Price		Price
6 x 30	$10.00	7 x 50	$14.75
8 x 30	11.25	16 x 50	17.50
7 x 35	12.50	20 x 50	20.00

"MILLIONS" of Lenses, etc. Free Catalogue

We pay the POSTAGE — C.O.D.'s you pay postage. Satisfaction guaranteed or money refunded if merchandise returned within 30 days.

NEW! 6" LENSES

Our 6" objective will not need high-pressure salesmanship. Its sparkling performance speaks for itself. Test one, or have any qualified person test it; we are certain that you will be satisfied. If not, take advantage of our money-back guarantee.

6" DIAM. AIR-SPACED TELESCOPE OBJECTIVE

Hard coated on 4 surfaces

f/10 - 60" focal length { MOUNTED ..... $175.00 ; UNMOUNTED .. 150.00

f/15 - 90" focal length { MOUNTED ..... 175.00 ; UNMOUNTED .. 150.00

We can supply ALUMINUM TUBING for the lenses above.

"GIANT" WIDE-ANGLE EYEPIECES

ERFLE EYEPIECE (65° field) contains 3 coated achromats. 1½" E.F.L., clear aperture 2⅛". Has a focusing mount with diopter scale. Will make an excellent 35-mm. Kodachrome Viewer. Magnifies seven times ..... **$12.50 ppd.**

Same as above without diopter scale **$9.95**

WIDE-ANGLE ERFLE (68° field) **EYEPIECE.** Brand new; coated 1¼" E.F.L. Focusing mount. 3 perfect achromats, 1-13/16" aperture **$13.50**

WIDE-ANGLE ERFLE 1½" E.F.L. Brand new; contains Eastman Kodak's rare-earth glasses; aperture 2"; focusing mounts; 65° field **$12.50**

1¼" Diam. Adapter for Erfle eyepieces **$3.95**

SPECIAL COATED OBJECTIVE BIG 2⅛" DIAM. — 40" F.L. — $6.00

These achromatic objective lenses are tested and have the same high quality as "Big Lenses" described at left, except they are seconds for slight edge chips or small scratches only. Quality guaranteed.

ONLY $6.00 ppd.

ASTRONOMICAL MIRRORS

These mirrors are of the highest quality, polished to ¼-wave accuracy. They are aluminized, and have a silicon-monoxide protective coating. You will be pleased with their performance.

	Diam.	F.L.	Postpaid
Plate Glass	3-3/16"	42"	$ 9.75
Pyrex	4¼"	45"	13.50
Pyrex	6"	60"	25.00

MIRROR MOUNTS, RACK-AND-PINION ● EYEPIECE MOUNTS, and ALUMINUM TUBING are available.

90° RIGHT-ANGLE PRISMS

8-mm. face	$1.00		
12-mm. face	1.00		
23-mm. face	1.25	Silvered	$2.00
28-mm. face	1.75	Silvered	2.50
38-mm. face	2.00	Silvered	2.75
48-mm. face	3.00	Silvered	4.00
62-mm. face, coated	$17.50		

TELEVISION PROJECTION LENS

Brand New, f/1.9, E.F.L. 5 inches. Manufactured by Bausch & Lomb. We purchased entire lot of these discontinued units. Five elements, smallest lens 2", largest 4⅛". Completely assembled 6" in length. All surfaces hard coated. Get this BARGAIN now.

ONLY $22.50

MOUNTED EYEPIECES

The buy of a lifetime at a great saving. Perfect war-surplus lenses set in black-anodized standard aluminum 1¼" O.D. mounts.

F.L.	TYPE	PRICE
6 mm. (¼")	Ramsden	$ 4.75
12.5 mm. (½")	Ramsden	4.50
12.5 mm. (½")	Symmetrical	6.00
16 mm. (⅝")	Erfle (wide-angle)	12.50
16 mm. (⅝")	Triplet	12.50
18 mm. (¾")	Symmetrical	6.00
22 mm. (27/32")	Kellner	6.00
27 mm. (1-1/16")	Kellner	4.50
32 mm. (1¼")	Orthoscopic	12.50
35 mm. (1⅜")	Symmetrical	8.00
55 mm. (2-5/16")	Kellner	6.00
56 mm. (2¼")	Symmetrical	6.00

COATED LENSES 75 cents extra.

GIANT "3" inch TELESCOPE

40 POWER postpaid **$57.50**

HIGH-POWER SPOTTING SCOPE — American Made. Big 3"-diameter achromatic coated objective will give bright crystal-clear images. Micrometer spiral focusing drawtube. Lightweight aluminum construction throughout, black crackle finish, length open 22", closed 15½". Upright image. Guaranteed to give superb performance.

8-POWER ELBOW TELESCOPE

This M-17 telescope has a brilliant image 48° apparent field — 325 feet at 1,000 yards. The telescope can be adjusted for focusing 15 feet to infinity. It has a 2" objective, focusing eyepiece 28-mm. focal length with an Amici erecting system. Turret-mounted filters: clear, red, amber, and neutral. Lamp housing to illuminate reticle for nighttime use. Truly the biggest bargain you were ever offered. Original Gov't. cost $200.

8 x 50

BARGAIN PRICE .... $13.50 ppd.

A. JAEGERS

6915 Merrick Road LYNBROOK, N. Y.

STARS FOR JUNE

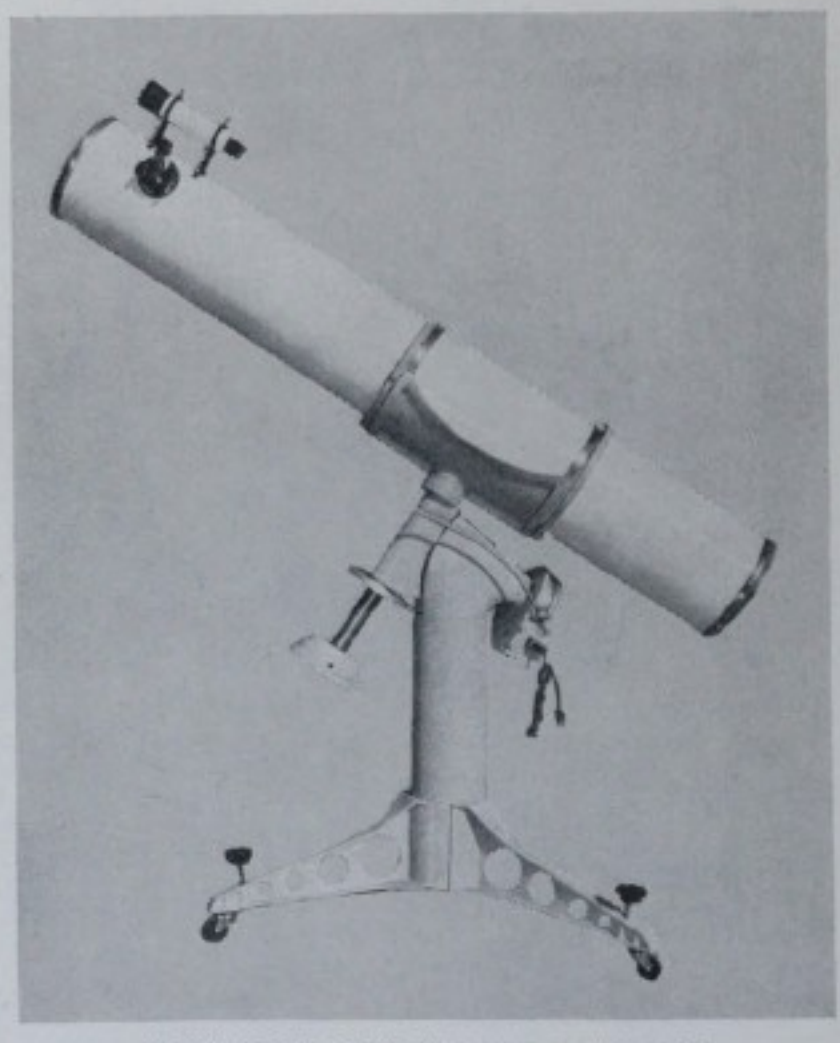
The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of June, respectively. For other dates, add or subtract ½ hour per week.

Near the southern horizon is a bright but unfamiliar area containing two constellations often overlooked because of nearby Scorpius. These are Centaurus and Lupus, the Centaur and the Wolf. An observer at latitude 40 degrees north can see two 2nd-magnitude and nine 3rd-magnitude stars here.

★ ★ TRECKERSCOPE ★ ★

NOW!...ALL MODELS WITH 1/20th WAVE

Now, as in the past, TRECKERSCOPE's high quality is the STANDARD OF COMPARISON! The first commercial American telescope to provide for amateurs 1/10th-wave optics again sets a new standard by offering to the purchaser optical systems with a correction of 1/20th-wave tolerance at regular prices. These tolerances of perfection, coupled with competitive prices, make available to the purchaser instrument quality formerly found only in high-priced custom telescopes! Avoid later disappointments by buying TRECKERSCOPE now!



SHOWN ABOVE IS THE 8" DELUXE TRECKERSCOPE

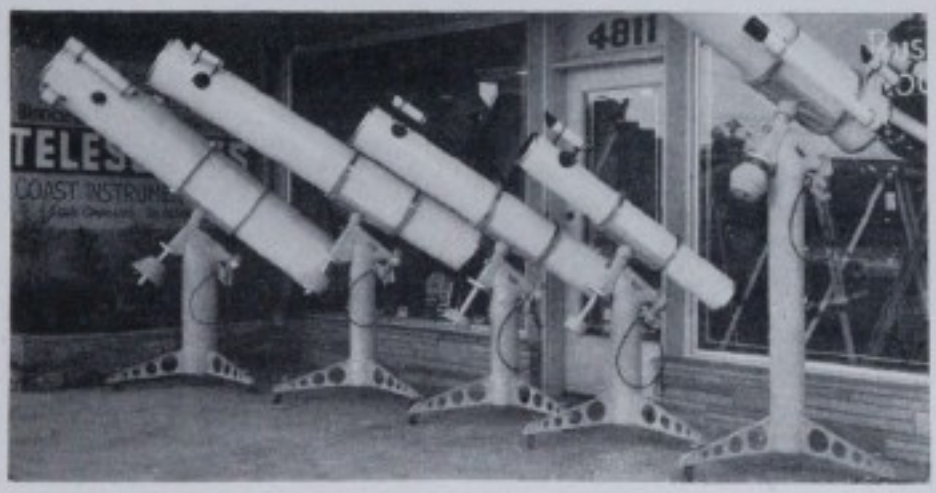
TRECKERSCOPE gives you BOTH beauty of design AND utmost perfection in construction and optical systems. Optional systems of f/7.5 or f/6 are available in the 8", 10", and 12½" models, and f/8 or f/5 in 6" models. All mounts are constructed so that the weight is carried at the lowest point possible, and, with fiberglass tubes, the weight on the saddle is reduced to an absolute minimum, thereby insuring a vibration factor of virtually zero. Columns of all models up to 10" are 6" in diameter, while the 12½" models are 8⅝" diameter. Rigidity is further increased by the use of 1½" SOLID-STEEL SHAFTING in the 6" and 8" mounts, and 1¾" SOLID-STEEL SHAFTING in 10" and 12½" models. Axle housings are our own design, massive special aluminum castings, aircraft type, cast in precise 90° configuration for utmost precision in tracking, and built to last a lifetime. Heads are fully adjustable for latitude. All TRECKERSCOPES are adaptable for fully portable use, or for permanent installation. The instruments may be completely disassembled, or assembled, in three minutes, and due to their relatively small individual components, may be easily carried in the family car to the viewing site when desired. Weights of the various models are approximately: 6", 75 lbs.; 8", 85 lbs.; 10", 115 lbs.; 12½", 145 lbs. (Shipped in sturdy wooden cases to insure perfect condition upon delivery to you.)

TRECKERSCOPE optical systems, NOW 1/20th wave, provide the finest viewing possible at any time, and on nights of best seeing give the ability of detecting minute lunar and planetary detail formerly only observable in telescopes of much higher price. Our own Coast Instrument mirrors, in all TRECKERSCOPES, are figured by one of the finest opticians in the world, and we invite any comparative test that is desired to prove that TRECKERSCOPE optics are, beyond shadow of doubt, of incomparably precise quality. Your selection of oculars, from our large stock, allows you to have exactly what you desire in the power range, by means of any three of our standard, orthoscopic ORTHO-STAR eyepieces, available in 6.6-mm., 10-mm., 16-mm., 20-mm., and 26.6-mm. focal lengths, or two of these superb oculars and the fabulous GOODWIN RESOLVING POWER (Barlow-type) LENS, which provides a wide variety of powers. All telescopes are star-tested before leaving our plant and are guaranteed to resolve to Dawes' limit. While most viewing will be done at relatively low powers, TRECKERSCOPES allow unbelievably high maximum power ranges, due to their 1/20-wave primaries, in excess of 500x in the 6", 650x in the 8", 800x in the 10", and 1,000x in the 12½", when viewing conditions are excellent.

Clock-driven assemblies on the TRECKERSCOPES are not only fine to behold, but they are built to last for a lifetime! The main-drive gear is 6" in diameter, 9/16" thick, of solid brass, precisely machined, and matched with a precision-ground worm gear and brass worm-drive gear. The latter is ⅛" thick and 3" in diameter, driving through a ⅝"-diameter hard-steel shaft, meshing with brass motor and flex-line gears. The entire unit is spring-loaded for the ultimate in smooth, precision tracking. Transmission of power to the polar axis is accomplished through a disk-type clutch, instantly overridden by hand pressure when desired. Flex-line control, TRECKERSCOPE's exclusive development, is included with all clock drives for manual operation.

Clock drive, setting circles accurate to 0.001 inch, fully rotating tube saddle assemblies, together with special contoured legs with casters for ease in moving the telescope from storage to viewing position (casters are snapped out when viewing), are all included in the deluxe TRECKERSCOPE models. Standard and deluxe models are otherwise identical as to mount and optical systems, and all deluxe accessories may be added to standard models whenever desired.

All mirrors are 100% aluminized and quartz over-coated, to government specifications, and, with reasonable care, these coatings can be expected to last more than 10 years before recoating is needed.



TRECKERSCOPES (from left to right) — 12½" DELUXE, 10" DELUXE, 8" DELUXE, 6" DELUXE, and 10" CASSEGRAIN "SKY-GIANT"

	STANDARD	DELUXE
6"	$ 325.00	$ 525.00
8"	399.50	599.50
10"	675.00	875.00
12½"	995.00	1,195.00

All prices f.o.b. our plant and subject to change without notice. Nominal crating charges apply to certain shipments. California residents add 4% sales tax. Extended payment plan available, up to 2 years to pay. Trade-ins accepted.

SEND FOR OUR NEW 68-PAGE CATALOG showing many of the other telescope items manufactured or distributed by COAST INSTRUMENT. It includes our treatise, "WHAT YOU SHOULD KNOW, LOOK FOR, AND DEMAND, BEFORE BUYING **ANY** TELESCOPE," an impartial, informative article that will give you information you've probably been looking for to help make up your mind as to just what telescope you should buy!

All prices, unless otherwise indicated, are at our warehouse in Long Beach, California, from where shipping charges will be added, and are subject to change without notice. Nominal crating charge added for all telescopes and mounts. California residents: Add 4% sales tax to all prices. NOW APPOINTING DEALERSHIPS . . . INQUIRIES INVITED.

TRECKERSCOPES ARE CUSTOM MADE IN AMERICA BY PROFESSIONAL OPTICIANS AND ENGINEERS.

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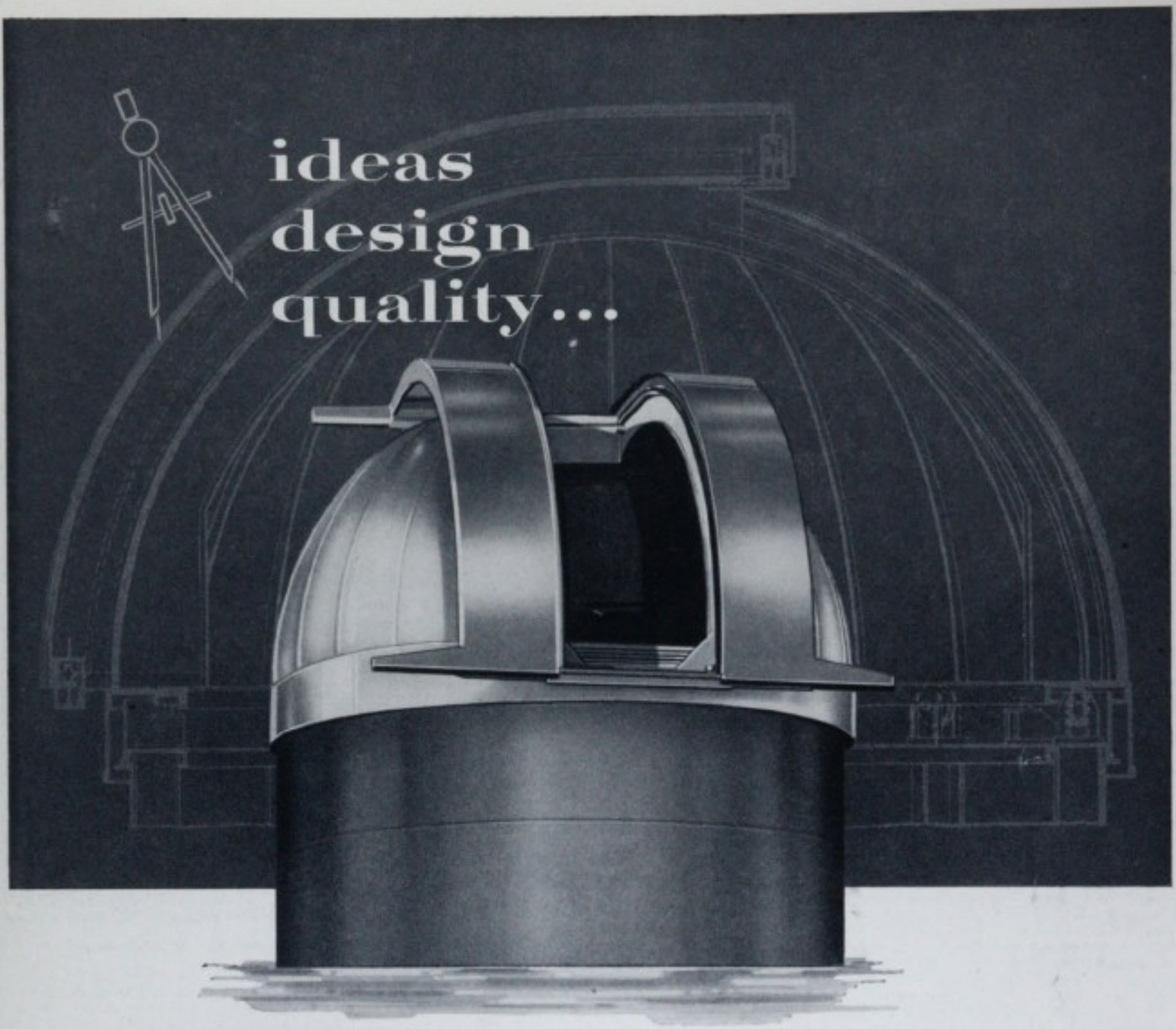
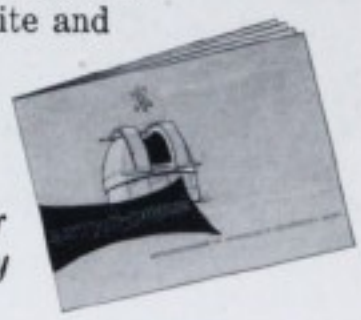


are FOREMOST in our production

We point with pride to the fact that we have installed more than fifty major and dozens of smaller ASTRO-DOMES in most of the United States, the Arctic, Antarctic, and five foreign lands. In addition, ASTRO-DOME has developed a whole new concept of dome design, from the rotating mechanism to the labyrinth seal shutters, which are now standard on all ASTRO-DOMES. Our engineering department has recently completed exciting new designs which are now in production. Write and find out how ASTRO-DOME can meet your requirements in the new space age.



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UNITRON's 4" Altazimuth Refractor

Here is the logical choice where requirements call for a large instrument and where budgets will not permit the purchase of a more expensive equatorial model. The UNITRON 4" Altazimuth Refractor, Model 150, is an ideal basic instrument to own. You can always add the equatorial mounting and clock drive, camera, photographic guide telescope, fixed pier, and other accessories.

The rock-sturdy altazimuth mounting is equipped with slow-motion controls and clamps for both altitude and azimuth. The 360° azimuth slow motion features a worm-gear mechanism. This complete refractor includes tripod and mounting, shelf for accessories, large 10x 42-mm. view finder, choice of UNIHEX Rotary Eyepiece Selector or star diagonal and erecting prism system, sunglass, solar aperture diaphragm, cabinets, and eyepieces for 250x, 214x, 167x, 120x, 83x and 60x. The UNITRON 4" Altazimuth Refractor is $465.00 complete. Put yourself at the controls for only $46.50 down.

See pages 448 and 449.

UNITRON INSTRUMENT DIVISION of UNITED SCIENTIFIC CO.
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